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ABSTRACT

This curriculum guide is designed to assist administrators and teachers of industrial arts and vocational and technical school programs with the development of a meaningful curriculum in the area of electricity and electronics. Included in the volume are curriculum guides for the following courses: Self- and Career Awareness of Electricity and Electronics, a course designed to expose elementary grade students to a variety of careers in the electrical and electronics fields; Exploring Electricity-Electronics, a course intended for use as an introduction for junior high school students; Basic Electricity-Electronics, a course that is geared toward students with a definite desire to learn the basics of components and circuits; Basic Applications of Electricity-Electronics, a course that deals with the servicing of consumer electronic devices; and Specialized Applications of Electricity-Electronics, an individualized curriculum for use with students who have special needs or interests. A 225-item bibliography concludes the guide. Appended to the guide are lists of publisher addresses, audiovisual producer and distributor addresses, film directories, electronics suppliers, teaching systems, and suggested tools as well as a glossary of electrical and electronics terms, an outline of significant events in the history of electricity and electronics, and a list of electrical and electronics symbols. (MN)

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Industrial Arts
Electricity/Electronics

A Curriculum Guide
for
Intermediate and Secondary
Level Programs

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PREFACE

This curriculum guide has been prepared as an aid to administrators and instructors of industrial arts and vocational-technical school programs for the development of meaningful curriculum in the area of electricity-electronics.[1] The guide has been divided into five sections: Pre-level I, Level I, Level II, Level III, and Level IV. Suggested curriculum in each level may be added-to or deleted-from to better fit the needs of students or to match resources and facilities of individual school districts. However, the curriculum has been written in a sequential fashion beginning with elementary concepts and progressively advancing to the complex. The goal is to insure all students enrolled in electricity-electronics programs benefit from their experiences.

Specifically, this guide reflects the approach of an instructional management system.[2] Thus, curriculum is organized with behavioral objectives clearly defined providing students precise knowledge of what must be mastered, what has been achieved as the school year progresses, and what remains to be accomplished. Also, all attempts have been made to correlate this guide to recent national standards developed for industrial arts programs.[3]

Pre-level I is entitled Self and Career Awareness of Electricity-Electronics. The purpose is to expose elementary grade students to the duties, responsibilities, required education, and personal traits required for a variety of careers in the electrical or electronics fields. The industrial arts instructor may have the opportunity to work with grade school instructors to achieve this goal and to actively recruit interested students for their program.

Level I, Exploring Electricity-Electronics, is intended for junior high and/or middle school students who wish an introductory course. The instructor has the opportunity to demonstrate as many concepts and principles as time permits in a non-technical manner, perhaps through the use of traditional shop projects.

Level II, Basic Electricity-Electronics Technology, is intended for students with a definite desire to know the basics concerning components and circuits. The instructor may utilize a class/lab format to describe theory and operation of passive and active components. This course is designed to provide the background of knowledge necessary for students to apply what they have learned.

Level III, Basic Applications of Electricity-Electronics (Consumer Product Servicing), further describes the basic circuits (power supplies, amplifiers and oscillators) and provides students the opportunity to apply their knowledge in the servicing of radios, televisions, stereos, and other consumer electronic devices.

Level IV, Specialized Applications of Electricity-Electronics, may be utilized in several ways. The course may normally follow Level III, giving students the opportunity to apply their knowledge to a variety of other applications (such as electrician), or the units of instruction may be used in an individualized manner for students with special needs or interests. Thus, individualized instructional curriculum can be obtained for most of the units of instruction suggested in Level IV.

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[1]Three helpful publications may be obtained by writing: Instructional Materials Laboratory, Industrial Education Building, University of Missouri, Columbia, MO 65201; **Handbook for Industrial Arts Education,** revised 1977, cost $3.50; **Planning and Equipping Industrial Arts Instructional Facilities,** revised 1977, cost $3.50; **Vocational Safety Guide,** 1981 edition, free.

[2]A copy of "Instructional Management: A Priority for Missouri Schools During the 1980's" may be obtained by writing Missouri Department of Elementary and Secondary Education, Industrial Arts Section, PO Box 480, Jefferson City, MO 65102.

[3]A copy of the "National Standards for Industrial Arts Programs" may be obtained by writing: AIAA Publications, 1914 Association Drive, Reston, VA 22091, cost, $4.00.

Acknowledgements

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Industrial Arts
Electricity/Electronics

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HOW TO USE THIS GUIDE

The five levels of instruction included in this guide are followed by lists of available text/reference books and manuals and audio-visual teaching aids; to include 16mm films, filmstrips, slides, transparencies and videocassette tapes. To use the guide effectively, the instructor should refer to these information lists often when preparing classroom and/or laboratory activities to determine available supporting materials. For example, the third unit of instruction for Level I is entitled "Introduction to Electricity". The following A-V material would be appropriate for use with this level: 16mm films, No. 1, 4, 5, 7, 11, 12, 13, 18, 20, 24, 32, 36, 47, 63, and 78 and filmstrips, Nos. 1 and 5. Note that each A-V title is followed by a letter code which represents the producer/distributor of the material. The meaning of these codes are listed in Appendix B. For example: 16mm film No. 1 for Level I is "A Is For Atom" followed by the code UMO. In Appendix B, UMO represents the University of Missouri, and the address is given. Catalogs of available A-V materials may be obtained by writing as well as informaiton concerning rental and/or purchase of the materials.

Additional appendices are included containing specific information. Appendix A lists publishers' addresses, Appendix C lists film directories, Appendix D lists electrical and electronic suppliers, Appendix E lists available teaching systems, Appendix F is a suggested tool and equipment list, Appendix G is a glossary of electrical and electronic terms, Appendix H is a list of significant events in electricity and electronics and Appendix I is a list of common electrical and electronic symbols.

It is my sincere hope that using this guide will make the task of preparing curriculum for your electricity and/or electronic programs much easier.

David C. Hilse

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Electricity-Electronics
Central Missouri State University
Warrensburg, Missouri

Point of View and Objectives

A principal purpose of American education is to assist individuals in their development as a productive member of society. The achievement of this purpose enables them to provide for their basic needs, to produce more than they consume, and to contribute more than they receive. It also involves the development of ideals and goals, the acceptance of social responsibility, and the acquisition of desirable character traits.

Behavorial changes within individuals are affected through experiences and the interpretation of these experiences. The experiences provided by the school permit one to acquire the skills and knowledges which allow individuals to develop to their maximum potential with profit to themselves and society. The learner's interpretation of these educational experiences provide for the further development of desirable character traits which lead to the wise application of the acquired skills and knowledges.

Industrial arts contributes to the purpose of American education by aiding individuals as they gain an understanding of their industrial-technological environment. In order that each individual may understand and learn to exercise some control over this environment, experiences in industrial arts must be an integral part of the overall educational program for all students, both boys and girls, and should be available at all grade levels. The importance of this experience is recognized in Missouri where credit in the practical arts, which includes industrial arts, is a secondary school graduation requirement.

Industrial arts education provides an opportunity for individuals to participate in direct experiences involving industrial skills and processes which fosters an awareness of industry in American culture. These expereinces are concrete, meaningful, and educational as they aid individuals in the understanding of abstract ideas. These experiences provide opportunities for individuals to apply mathematics, science, art, language arts, and other school subjects in purposeful situations.

Through the application of grouping and special instructional techniques, industrial arts in the secondary school can be organized to meet the needs of students of varying abilities. Individuals expecting to enter professional occupations as well as future industrial workers should benefit from industrial arts experiences. The need for industrial arts instruction has little relationship to the economic status of the student. Individuals must be aware of and familiar with the concepts taught in industrial arts education if they are to live effectively in our industrial society.

Industrial arts education aids in the discovery and development of personal interests, aptitudes, creative thinking, and technical abilities. Responsible and resourceful actions and judgments are matured through problem solving and self-expression in an environment related to industry. The future scientist or engineer may learn to solve technical problems, and the future technician or craftsman may develop skills and related understandings in industrial arts courses.

Realistic objectives, clearly stated, are essential to a sound program of industrial arts education. The following statements of purpose are fundamental to quality industrial arts education as it provides opportunities for students to:

Develop an insight and understanding of tools, machines, materials, and processes as they relate to the production and servicing aspects of industry.

The field of industrial arts education is concerned with the study of materials and processes of industry and the creative use of design. Students of industrial arts education have an opportutnity to gain a better undertanding of mass production, automation, and other industrial methods if they actively participate in meaningful experiences dealing with the manufacturing of consumer goods, utilization and generation of energy as well as the servicing, testing, and repairing of industrial products.

Discover and develop abilites, aptitudes, and interests related to the technical pursuits and applied sciences.

Opportunities for students to have experiences which assist in the discovery of abilities and to develop their potentialities to the fullest is essential to the basic education of all youth. Allowance for differences of abilities, interests, and needs should be incorporated into the curriculum offerings so students can better assess their abilities for making an occupational choice, understanding their environment, and preparing themselves to meet the changing demands of a technological society. Occupationally oriented industrial arts programs shall be designed to: 1) assist individuals in making informed and meaningful occupational choices and, 2) prepare individuals for enrollment in advanced or highly skilled vocational and technical programs.

Develop basic skills in the safe and proper use of industrial materials, tools, machines, and processes.

Students are provided with experiences which help them develop basic skills relevant to industrial production. Servicing students through these experiences helps them gain a basis for making occupational choices. In addition, the skills provide a basis for a specialized occupational preparation. Many workers of the future will be required to train and retrain for different occupations during their lifetime. Fundamental skills and knowledge in diversified areas are most essential if this retraining is to be accomplished in an efficient manner.

Develop problem-solving and creative abilities relating to the tools, machines, materials, processes, and products of industry.

The industrial arts education program provides opportunities for solving various types of technical problems through experimentation and research as well as project planning and construction. The industrial arts laboratory setting provides an environment which makes possible a concrete, understandable approach to teaching problem-solving and critical thinking. Problem-solving in industrial arts education involves creative thinking and provides experiences which allow students to find solutions to problems and to evaluate the effectiveness of these solutions.

Develop an understanding of industrial and technological career opportunities and their requirements plus develop those traits which will help students obtain and maintain employment.

Industrial arts involves the preparation, growth, and guidance of the individual student for modern living through an instructional program including the technical, consumer, occupational, recreational, organizational, social, historical, and cultural aspects of industry and technology. While industrial arts utilizes and motivates general education learning experiences, its scope and sequence of courses have a direct relationship to vocational education as well as career education concepts.

This objective is supported by statements from the Code of Federal Regulations for the Organization and Operation of Industrial Arts under the Vocational Education Act.

In 1972, Congress recognized the importance of industrial arts and its objectives by adding it to the Vocational Education Act (V.E.A.) making the benefits to vocational subjects also available to industrial arts courses when they fulfill one or more objectives of the act. Industrial arts has a direct relationship to programs of trade and industrial education and technical education. Federal regulations released in the **Federal Register** of November 21, 1973 outline the function of industrial arts and serve as a guide for the establishment of an approved and fundable program.

1. Definition:
"(q) 'Industrial arts education programs' means those education programs (1) which pertain to the body of related subject matter, or related courses, organized for the development of understanding about the technical, consumer, occupational, recreational, organizational, managerial, social, historical, and cultural aspects of industry and technology including evaluating, and using tools, machines, materials, and processes which provide opportunities for creativity and problem solving and assisting individuals in the making of informed and meaningful occupational choices. . ."

2. Objective of Instruction:
Instruction shall be designed to:
"(i) Assist individuals in the making of informed and meaningful occupational choices. In order to accomplish or facilitate this purpose, such programs shall:
"(a) Provide occupational information and instruction pertaining to a broad range of occupations, including training requisites, working conditions, salaries or wages, and other relevant information;
"(b) Provide exploratory experiences in shops, laboratories, and observations in business or industry to acquaint students with jobs in the occupations included in this purpose; program under Sec. 102.4(b)(5) of this part to assist them in making informed and meaningful choices in selected occupational fields; and
"(d) Employ industrial arts teachers who have qualifications as provided in the State plan pursuant to Sec. 102.38; or
"(ii) Prepare individuals for enrollment in advanced or highly skilled vocational and technical education programs. In order to accomplish or facilitate this purpose, such programs shall:
"(a) Provide individuals with occupational information and exploratory experience for enrollment in such program;
"(b) Provide occupational information and exploratory experiences directly related to current practices in industry; and
"(c) Be conducted in an institution approved by the State Board of Vocational Education and by industrial arts teachers and guidance and counseling personnel who have qualifications as provided in the State plan pursuant to Sec. 102.38."

3. Industrial Arts Youth Organizations:
"(j) Industrial arts youth organizations. Industrial arts education programs may provide for students to participate in club activities as an integral part of the instruction which are offered as indicated by Sec. 102.4 and which are supervised by industrial arts personnel."

Pre-Level I
Self and Career Awareness Of Electricity-Electronics

Pre-Level I is included to provide industrial arts instructors suggestions concerning career opportunities in the field of electricity-electronics. It is suggested that this information be shared with elementary grade students in an attempt to heighten their awareness of possible career choices. This may best be accomplished through discussions and question/answer sessions with these students, providing information concerning duties and responsibilities of each career along with the amount of education required. Safety considerations for all careers should also be stressed. Much consumer information can be passed along during these sessions to provide elementary students insight concerning how to become wise consumers of commercially available products, especially electrical and electronic products.

Demonstrations of basic electrical and/or electronic principles and concepts may be utilized by the instructor to create student interest and direct discussion. Many of the demonstrations used in your regular classroom/laboratory sessions will undoubtedly be appropriate. The demonstrations will gain student interest and most likely generate a good deal of discussion.

As a further suggestion to instructors, slides may be made of local community industries to be used with discussion sessions. Also, local business representatives serving as guest speakers will greatly enhance these presentations.

By participating in these sessions, it is hoped you will eventually benefit by gaining interested students in your programs when they have reached the appropriate grade level; not to mention providing a service to your school district as well as to the advancement of industrial arts education.

The numbers listed below refer to bibliographic information designated for this level. To acquire more detailed information for each number, turn to the Selected Bibliography section in this guide and match the number with the corresponding reference.

Bibliographic reference numbers: 145, 156, and 187.

Pre-Level I
Behavioral Objectives For
Self And Career Awareness Of
Electricity-Electronics

Upon completion of this course of study, the student will be able to:

1. Discuss duties and responsibilities of a specific electrical and/or electronic career.
2. Discuss educational requirements to meet a specific career goal in an electrical and/or electronic occupation.

Pre-Level I
Self And Career Awareness Of
Electricity-Electronics

For all occupations:

Teacher activities should consist of discussions concerning duties and responsibilities, necessary education, and future possibilities of each occupation.

Student activities may consist of question and answer sessions with the Industrial Arts teacher and/or representatives from industry.

Level I
Exploring Electricity-Electronics

Level I curriculum was developed to aid industrial arts instructors prepare classroom and laboratory activities in the field of electricity-electronics for junior high and middle school students. In most cases, this will represent the student's first formal opportunity for experiences in this area. Therefore, the experiences should be of a nature to awaken student interest and arouse curiosity. The student should be given an opportunity for exploratory manipulative experiences with as many devices and concepts as maturity and ability may warrant.

While some degree of uniformity in industrial arts progams is desirable, this goal may not always be possible. Thus, this guide has been prepared with a certain amount of flexibility in mind. Instructors may achieve this flexibility by varying the emphasis placed upon certain units of instruction and by varying the degree and kinds of student manipulative experiences in these units. Instructors desiring greater emphasis in the area of electricity and/or electronics will find sufficient material in this guide to meet their needs.

While sequence of instructional units and course content is a matter of individual preference, this guide has been arranged to enable the instructor to direct student activities in a meaningful and logical manner. Experiences arranged in the suggested sequence will allow for progression from elementary to more advanced concepts, with each unit of instruction providing a foundation of knowledge for the units which follow.

The following behavioral objectives are concepts and principles students at Level I should possess upon completion of these instructional units.

The numbers listed below refer to bibliographic information designated for this level. To acquire more detailed information for each number, turn to the Selected Bibliography section in this guide and match the number with the corresponding reference.

Bibliographic reference numbers: 7, 23, 35, 49, 53, 54, 55, 64, 92, 98, 109, 117, 122, 135, 146, 152, 157, 212, and 215.

Level I
Behavioral Objectives
For Exploring Electricity-Electronics

Upon completion of this course of study, the student will be able to:

1. List electrical hazards at the work place.
2. Describe procedures for minimizing electrical hazards at the work place.
3. Draw symbols of electric components.
4. Interpret elementary electrical drawings.
5. Define voltage, current, resistance, and power.
6. Describe static, chemical, photoelectric, thermal piezoelectric, and electromagnetic sources.
7. Define requirements for the simplest electric circuit.
8. Describe conductors, insulators and semiconductors.
9. Define series, parallel, and series-parallel electric circuits.
10. Describe relationships between voltage, current, resistance, and power.
11. Describe effects of current flow through a circuit.
12. Define magnetism and electromagnetism.
13. Use a multimeter to measure resistance, voltage, and current.
14. Calculate electric quantity values using Ohm's and Watt's Laws.
15. Describe operation of electric devices such as motors, transformers, relays, solenoids, fuses, and circuit breakers.
16. Make correct solder joints.

OCCUPATION	DUTIES & RESPONSIBILITIES	EDUCATION
I. Electrician		
Residential.	Troubleshoot malfunctioning wiring circuits.	High School or Apprentice Program.
Commercial.	Design wiring circuits.	
Industrial.	Installation of wiring circuits.	
II. Appliance Servicing		
	Troubleshoot malfunction of heating and motor-type appliances. Replace defective parts to repair appliance.	High School or Apprentice Program.
III. Radio and Television Servicing		
	Troubleshoot malfunction of AM radio, FM radio, black & white and color TV. Replace defective parts to repair receiver.	High School or Associate of Science degree.
IV. Electrical Technician		
	Troubleshoot malfunctioning electrical systems: • motors and motor controls • transformers • heating and cooling systems • replace defective parts to repair systems.	High School or Associate of Science degree.
V. Electronic Technician		
	Same as for radio & TV servicing. However, the technician can troubleshoot *other* types of equipment as well.	High School or Associate of Science degree.
VI. Electrical and/or Electronic Technologist		
	Same as for the Electronic Technician. However, the technologist has basic knowledge of circuit design as well as troubleshooting skills.	Bachelor of Science degree.
VII. Electrical and/or Electronic Engineer		
	Same as for the technologist. However, the enginer has advanced knowledge of circuit design and is not usually involved in troubleshooting.	Bachelor of Science degree and/or Master of Science degree.
VIII. Electrical and/or Electronic Scientist		
	May be the same as an engineer but with additional education (often engineers fill the role of scientist).	Bachelor of Science degree and/or Master of Science degree and/or Doctor of Philosophy degree.
IX. Electrical and or Electronic Sales Representative		
	Knowledge of the operating principles of merchandise. Salesmanship techniques. Proper business practices.	High School or beyond.
X. Industrial Arts Teacher		
	Knowledge of electricity and electronics used in industry.	Bachelor of Science degree.

Level I
Exploring Electricity-Electronics

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
I. Safety Practices		
Shop Safety	Discuss safe shop practices and the proper use and care of tools and equipment.	Successfully pass quizzes concerning shop safety and proper use and care of tools and equipment.
II. Opportunities in the World of Electricity and Electronics		
Career opportunities.	Discuss areas of employment opportunity.	Write a short report on some area of employment in the electricity-electronics field.
III. Introduction to Electricity		
The atom and the electron.	Use transparencies or charts to explain theory of atomic structure.	Draw diagrams of several simple atoms and label the particles.
	Demonstrate laws of electrical charges.	Draw diagrams of an atom to show positive, negative and neutral conditions.
Electrical quantities.	Define voltage, current, resistance, and power and discuss their relationships.	Write the definitions of voltage, current, resistance, and power.
Electrical sources.	Define static, chemical, thermal, photo, piezo, and electromagnetic sources.	State how these sources produce voltage.
Conductors, insulators, and semiconductors.	Define conductors, insulators and semiconductors.	Make lists of conductor and non-conductor materials.
	Show examples of various materials used as conductors and non-conductors.	State differences between conductor and non-conductor materials
	Show flow of electrons through a conductor with mock-up or animation.	Define semiconductor materials.
	Discuss semi-conductor materials and their characteristics.	
Resistance and the ohmmeter	Define resistance.	Use an ohmmeter to study silicon diodes for forward and reverse effect.
	Demonstrate use of the ohmmeter.	Use an ohmmeter to study resistive materials.
	Demonstrate factors which affect resistance.	Use knowledge of color coding to determine resistance of various resistors and check with ohmmeter.
	Introduce students to resistors and show how resistance changes with color coding.	

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Effects of current flow.	Explain the characteristics of nichrome and other resistive conductors.	Experiment with nichrome wire and DC voltage to produce heat.
	Demonstrate how heat from a wire varies with length, voltage, and size.	Determine the factors which influence the amount of heat a wire will produce.
	Show examples of the different kinds of lamps, discuss operation and uses.	Examine the construction of commercial heating elements.
		Experiment with the different kinds of lamps, their operation and uses.
	Demonstrate that resistors get warm in an electric circuit.	
	Demonstrate how current flowing through a circuit affects a compass needle.	
IV. Magnetism and Electromagnetism		
Magnetism.	Discuss atomic theory of magnetism.	Use bar magnets to study laws of magnetism.
	Use chart to show how magnetized and demagnetized steels differ in atomic structure.	Study lodestones and learn why they become magnetized.
	Using a coil operating on AC voltage, show how to demagnetize a horseshoe magnet.	Use bar and horseshoe magnets to study field patterns with iron filings.
	Using a coil operating on DC voltage, show how to re-magnetize a horseshoe magnet.	De-magnetize and magnetize a horseshoe magnet.
	Demonstrate broken magnet effect.	State technology of magnets and magnetic fields.
Magnetic and non-magnetic materials.	Demonstrate iron vs. copper with permanent magnet.	State why iron can be magnetized while copper cannot.
	Describe atomic structure of magnetic vs. non-magnetic material.	
Electromagnetism.	Define electromagnetism.	Use a hollow core electromagnet with removable soft iron and steel cores to discover residual magnetism.
	Discuss electron theory of electromagnetism.	Study field effects of electromagnet operating on both AC and DC voltage.
	With a compass and DC voltage, show field around current-carrying wire. Show how polarity is determined.	Try to hold a piece of aluminum on shop-made electromagnet operating on AC voltage.
	Discuss field effects around a coil.	Determine factors affecting the strength of an electro-magnetic field.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
V. Electric Quantities		
Voltage and the volt.	Review information previously presented concerning voltage.	Define the terms "EMF," "voltage," "potential difference," and "voltage source."
	Demonstrate the proper way to connect a voltmeter to a circuit.	Connect a voltmeter to a circuit.
	Demonstrate the use of the voltmeter, range settings, function of controls, etc.	Describe the function of the voltmeter and its controls.
	Set a mock-up on various readings throughout its ranges for students to read.	Practice reading the volt meter on its various scales from a mock-up.
		Practice taking various voltage readings on AC & DC circuits.
Current and the ampere.	Review information previously learned concerning current and amperes.	Define the terms "ampere," "current," and "milli-ampere."
	Demonstrate the proper way to connect an ammeter in a circuit.	Connect an ammeter in a circuit.
	Set a mock-up on various readings on all ranges to give the student practice in reading an ammeter.	Read an ammeter on its various ranges by taking practice readings on a mock-up.
		Construct various low voltage circuits in series and parallel and take current readings with an ammeter and milliammeter.
Resistance and the ohm.	Review information previously learned regarding resistance.	Define the terms "resistance" and "ohms."
	Have students read various settings of an ohmmeter mock-up.	Read an ohmmeter on its various ranges.
	Demonstrate proper method of connecting an ohmmeter to a circuit.	Connect an ohmmeter to a circuit.
Power and the watt.	Explain that the watt is basically volts times amperes.	Define "power" and "watt."
		Define the terms "kilowatt" and "kilowatt hour."
		Read a kilowatt hour meter.
VI. Simple Electric Circuits		
Electrical symbols.	Discuss the importance of electrical symbols and why they are used.	Draw symbols for the common electrical components.
	Use "flash cards" to assist students in learning to recognize symbols.	Use a component identification board to learn to match component with symbol.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Wiring diagrams.	Discuss the structure of series and parallel circuits.	Draw wiring diagrams of low voltage series and parallel lamp circuits and wire these circuits.
Series circuits.	Demonstrate how current and voltage behave in series.	State the characteristics of a series circuit.
Parallel circuits.	Demonstrate how current and voltage behave in parallel.	State the characteristics of a parallel circuit.
Series-parallel circuits.	Discuss characteristics of neon lamp circuits and how they operate.	Wire different flashing neon lamp circuits from diagrams, in progressive order of difficulty.
VII. Electrical Laws		
Resistance in series.	Explain how to compute the total resistance of a series circuit.	Hook up resistors in series, compute and measure total resistance.
Resistance in parallel.	Explain how to compute the total resistance of a parallel circuit.	Hook up resistors in parallel, compute and measure total resistance.
Ohm's Law formulas.	Explain Ohm's Law symbols and formulas.	Describe Ohm's Law formulas.
	Demonstrate Ohm's Law relationships.	State and observe Ohm's Law relationships.
	Explain and demonstrate how voltage behaves in a series circuit.	Compute and measure voltage in a series circuit.
	Explain and demonstrate how voltage behaves in a parallel circuit.	Compute and measure voltage in a parallel circuit.
Watt's Law.	Explain effect on circuit power when voltage is doubled.	Connect voltmeter and ammeter in a circuit to determine the power in watts consumed.
	Explain effect on circuit power when resistance is doubled.	
VIII. Sources of Electricity		
Electrostatics.	Demonstrate ways to make static electricity.	Use fur, cloth, and rods to produce static electricity.
	Demonstrate the use of an electroscope.	Experiment with an electroscope.
	Discuss industrial applications of static electricity.	Study the effects of static electricity.
Cells and batteries.	Discuss different battery types.	Make a "coin cell" or "lemon cell" and measure its potential with a sensitive meter.
	Explain why some batteries can be recharged and others cannot.	Study primary and secondary cell structure and characteristics.
		Connect dry cells in series and in parallel and study the results.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Generators and alternators.	Define induction.	Use a telephone generator and argon bulb to produce alternating current and observe its action.
	Demonstrate how to produce a voltage across a coil with a magnet.	With a coil, magnet, and center reading meter, produce a voltage by induction.
	Discuss the principles of operation of the generator.	Hook up an experimental motor so that it will function as a generator and observe its output.
	Discuss AC and DC generators.	State the difference between AC and DC generators.
Photo-electric cells.	Discuss the uses of photo-electric cells.	Experiment with a solar cell.
		Study and experiment with photo-voltaic and photo-resistive cells.
Thermocouples.	Discuss the uses of the thermocouple in industry.	Experiment with a thermo-couple, using a source of heat and a meter.
Piezo-electricity.	Explain the term piezo-electricity and how electricity is produced in this manner.	Observe the output of a phonograph cartridge on scope or meter.
IX. Electric Circuits and Control Devices		
Switches.	Identify the electrical characteristics of a switch from its appearance and with a meter.	Draw symbols for SPST, SPDT, DPST, DPDT, and rotary switches.
	Discuss applications for the various types of switches.	Show examples of each type of switch, using knife switches when possible.
		Using lamps, diagram and wire various low voltage switching circuits.
		Diagram and wire a switch circuit to reverse a small electric motor.
		With a rotary switch, diagram and wire a circuit to control several branch circuits.
Solenoids.	Demonstrate the action of devices employing solenoids in their operation.	Experiment with a hollow core coil and soft iron core to observe solenoid action.
		Diagram and wire a circuit controlled by a solenoid.
Relays.	Explain relay operation and function.	Wire circuits involving one or more relays.
		Draw wiring diagrams for relays and relay circuits.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Transformers.	Discuss transformer theory.	Using an experimental transformer, wind on several different secondaries and measure voltage of each.
	With the shop-made electromagnet, extra core, coil and NE-2 lamp, demonstrate electromagnetic induction. Using DC voltage, switch coil on and off rapidly to produce moving magnetic field which NE-2 lamp indicates. Show how AC voltage produces this field without switching.	Draw symbols for various types of transformers.
		Draw diagrams of circuits requiring transformers.
		Describe transformers action.
Fuses and circuit-breakers.	Demonstrate need for over-current protection.	State reasons for over-current protection.
	Demonstrate deficiency of "Abe Lincoln" fuse.	Study and examine various protective devices.
		Locate and reset a thrown breaker.
		Locate and replace a blown fuse.
DC controls.	Explain purpose and operation of a rectifier.	Study rectifiers and diodes and observe their action with a scope.
	Explain various types of rectifier circuits, such as full wave, half wave, filtered and unfiltered, etc.	From a wiring diagram, wire a simple power supply and observe current at various stages with a scope.
X. Applications of Electricity		
Motors.	Discuss motor theory.	Experiment with a St. Louis motor.
Communications.	Discuss operation of telegraph.	Experiment with simple telegraph key and sounder. Option to learn code.
	Discuss operation of the telephone.	Experiment with telephone circuits.
	Discuss operation of TRF radio receivers.	Construct simple radio receiver using diodes and transistors. Work from wiring diagram. Test each one.
Space and power.	Discuss the importance of electricity in space exploration.	Write a short report explaining how electrical discoveries have made space exploration possible.
	Discuss methods of producing electrical power.	Write a short report on the use of atomic energy to produce electricity.
	Discuss alternate energy sources.	

Level I
Exploring Electricity-Electronics
See Appendix B for Producer/Distributor Addresses

16mm Films

1. A is for Atom - UMO
2. AB Circuit Breakers - WEC
3. A Missle Named Mac - ATAT
4. Amperes, Volts, and Ohms - TAI
5. Atom and the Kilowatt - UMICH
6. Atomospheric Electricity - UMO
7. Basic Electricity: A Series - USNAC
8. Battery Electricity - UILL
9. Beyond All Barriers - ATAT
10. Charging Storage Batteries - TAI
11. Conductors and Semiconductors - ATAT
12. Current and Electromotive Force - USN
13. Effects of Electric Current - UMO
14. Electric Circuits - UMO
15. Electric Circuit Faults - NETFS
16. Electric Field and Potential - UMO
17. Electric Motors - UMO
18. Electrical Sources - UMO
19. Electrical Workers - PUAVC
20. Electricity for Beginners - UMO
21. Electricity: From Power Plant to Home - UMO
22. Electricity: Handle with Care - UMO
23. Electricity: How to Make a Circuit - EBEC
24. Electricity in Motion - UMO
25. Electricity: Measurement - IU
26. Electricity: Static Electricity - IU
27. Electricity: The Way it Works - UMO
28. Electromotive Force of a Battery Cell: Lab Demo - UMO
29. Electromagnets: How They Work - UMO
30. Electronics - SF
31. Electrostatics - UMO
32. Elementary Electricity: Amperes, Volts and Ohms - USNAC
33. Elements of Electrical Circuits - UMO
34. Exploring Electromagnetic Energy - UMO
35. Functional Teaching of Basic Electricity and Electronics - USN
36. Fundamentals of Electricity - UMO
37. Heat and Light from Electricity - NETFS
38. Horsepower: Lab Demo - UMO
39. How an Electric Motor Works - UMO
40. How Magnets Produce Electricity - USN
41. How To Produce Electric Current with Magnets - UMO
42. How Transformers Work - MSU
43. I'm No Fool with Electricity - UMO

Level I
Exploring Electricity-Electronics

16mm Films (cont'd)

44. Induced Electric Currents - UMO
45. Inductance - ALLISC
46. Introduction to Cathode-Ray Oscilloscopes - UMO
47. Learning About Electric Current - UMO
48. Learning About Magnetism - UMO
49. Magnetic Effects of Electricity - UILL
50. Magnetic, Electric and Gravitational Fields - UMO
51. Magnetic Fields - UMO
52. Magnetic Force - UMO
53. Magnetic Induction - UMO
54. Magnetism - CORF
55. Making Electricity - UMO
56. Measurement of Electricity - CORF
57. Mechanical Generation of Energy - MSU
58. Mr. Bell - ATAT
59. Ohm's Law - UMO
60. Parallel Circuits - UMO
61. Parallel Resistance: Lab Demo - UMO
62. Plane Talk - ATAT
63. Pressure and Current - UMO
64. Principles of Electricity - UMO
65. Principle of the Generator - NETFS
66. Project Telstar - ATAT
67. Series Circuits: Lab Demo - UMO
68. Series and Parallel Circuits - UMO
69. Sources of Electricity - UILL
70. Static Electricity - UMO
71. Study of Motors - UMO
72. Telephone Lineman - PUAVC
73. Television Workers - PUAVC
74. The Bell Solar Battery - ATAT
75. The Electrician - UMO
76. Using Ohm's Law to Understand Circuits - MSU
77. Watts, Watthours, and Watthour Meters - MSU
78. What is Electric Current - UMO

Level I
Exploring Electricity-Electronics

Filmstrips

1. Basic Electricity and Electronics: Direct Current - BGW
2. Developing Shop Safety - AAVIM
3. Energy Alternatives - BGW
4. How Electric Motors Start and Run - AAVIM
5. Safety Color Coding for the Shop - AAVIM

Slides

1. Developing Shop Safety - AAVIM
2. Electric Energy - AAVIM
3. Electric Motors - AAVIM
4. How Electric Motors Start and Run - AAVIM
5. Understanding Electricity and Electrical Terms - IML
6. Safety Color Coding for the Shop - AAVIM

Transparencies

1. Basic Electronics I - IML
2. Electric Energy - AAVIM
3. Electric Motors - AAVIM
4. Understanding Electricity and Electrical Terms - IML

Level II
Basic Electricity-Electronics Technology

Level II curriculum was developed to present a broader field of knowledge with in-depth experiences for students who have developed an interest in and who realize the need for further study in the field of electricity-electronics.

The curriculum begins with units of instruction at the elementary level, which may serve as review for former Level I students, and progresses through passive and active component theory. Thus, students will become familiar with the construction, operation, and uses of resistors, inductors, capacitors, diodes, transistors, vacuum tubes and integrated circuits. This knowledge of components will enable the student to progress to the level of understanding required for circuit troubleshooting and repair. (See Behavioral Objectives for Level II.)

Specific applications of electricity-electronics (such as Residential Wiring) may be included with Level II curriculum, or left to Level IV where specialized applications of electricity-electronics are presented. The instructor should keep in mind that this guide may be used in a variety of ways to meet the specific requirements of the students.

Suggested teaching time is one period per day, five days per week for thirty-six weeks. Ninth, tenth, eleventh, and twelfth grade students who desire to learn more about basic electricity-electronics may enroll in this course.

The numbers listed below refer to bibliographic information designated for this level. To acquire more detailed information for each number, turn to the Selected Bibliography section in this guide and match the number with the corresponding reference.

Bibliographic reference numbers: 6, 7, 8, 9, 10, 16, 17, 19, 20, 22, 28, 29, 31, 33, 35, 38, 39, 46, 47, 48, 50, 52, 53, 56, 58, 59, 60, 63, 64, 69, 72, 75, 77, 78, 79, 81, 88, 93, 97, 98, 99, 104, 109, 113, 115, 116, 119, 123, 124, 131, 134, 136, 141, 144, 150, 151, 154, 155, 160, 161, 162, 176, 177, 183, 184, 185, 191, 193, 194, 195, 199, 200, 203, 204, 207, 210, 211, 213, 214, 219, 220, 221, 222, and 225.

Level II
Behavioral Objectives for
Basic Electricity-Electronics Technology

Upon completion of this course of study, the student will be able to:

1. Demonstrate safe working procedures with electricity.
2. Make a proper solder connection.
3. Describe functions of resistive DC and AC series, parallel and series-parallel circuits.
4. Calculate electric quantities using Ohm's and Watt's Laws.
5. Describe characteristics of inductance and capacitance with DC and AC sources.
6. Discuss uses for resistance in electric circuits.
7. Discuss uses for inductance in electric circuits.
8. Discuss uses for capacitance in electric circuits.
9. Explain how inductors and capacitors behave in circuits with either an AC or DC source.
10. Define reactance, impedance, and resonance.
11. Describe characteristics of inductive-capacitive resonant circuits.
12. Describe operating principles of electric generators.
13. Describe operating principles of electric motors.
14. Describe operation of semiconductor and vacuum tube diodes.
15. Describe operation of bipolar transistors.
16. Describe operation of triode, tetrode, and pentode vacuum tubes.
17. State common uses of active devices (transistors, vacuum tubes, and integrated circuits).
18. Describe characteristics of operational amplifiers.
19. Describe characteristics of microprocessors.
20. State uses for microprocessors.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
I. Introduction		
Class objectives and policies.	Discuss behavioral objectives with class.	Discuss the purpose of this course.
Safety and first aid care, and use of tools and equipment.	Demonstrate proper ways to use tools and equipment.	Study shop safety.
	Display electricity-electronics equipment.	State purposes for test instruments.
	Demonstrate proper way to make a solder joint.	Practice making correct solder connections.
Occupational opportunities.	Discuss job opportunities.	Describe industrial job opportunities and leisure time activities in the electricity-electronics field.
Famous people in the field of electricity.	Discus famous people in electricity.	Prepare a written paper on important people in electricity.
II. Basic Concepts		
Atomic theory.	Discuss the atom and the electric field.	Identify particles of an atom and their proper charge.
Laws of charges, conductors, insulators, and semiconductors.	Demonstrate the insulative and conductive ability of various materials.	Compare elements as conductors and/or insulators using the element chart.
Static and dynamic electricity.	Demonstrate ways to make static electricity.	Produce static electricity by rubbing dissimilar objects together.
Sources of electricity.	Discuss methods for producing electromotive force.	Describe six common sources of DC voltage.
Electrical symbols.	Define the common component symbols.	Draw the common component symbols.
Schematic diagrams.	Draw sample circuits on chalkboard using schematic symbols.	Describe a simple electric circuit as a schematic diagram.
Block diagrams.	Depict an electrical system in block diagram form.	Complete a block diagram of an A.M. radio receiver.
Wiring diagrams.	Define wiring diagrams pertaining to residential electric circuits.	Complete a wiring diagram for a three-way residential switching circuit.
Multimeter familiarization.	Describe the operation of each function of the multimeter.	Practice reading multimeter scales.
		Collect and check examples of insulators, conductors, and semiconductors with a meter.
		Complete a performance test for each function of the multimeter.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
III. Basic Electrical Quantities		
Volt and voltage.	Discuss why voltage must exist across a load before current can flow through it.	Define voltage, potential difference, and electromotive force.
Ampere and current.	Define current as the flow of electrons.	Define current and the ampere.
Coulomb and charge.	Define charge as current at rest.	Explain the electrostatic field that exists between two unlike electric charges with the ability to store an electric charge.
	Define one coulomb as approximately 6.24×10^{18} electrons.	
Ohm and resistance.	Display and discuss various resistors.	Study copper wire table and compare wire sizes with the amount of resistance each has.
	Define resistance as the opposition to current flow.	
Factors influencing resistance.	Discuss carbon and wirewound resistors and reasons they posses different resistance values.	Examine and disassemble several resistors.
		Measure the resistance of different types of resistors with an ohmmeter.
Resistor color code.	Explain the color code used with carbon resistors.	Practice the use of the resistor color code to "read" the value of specific carbon resistors.
Mho, siemens, and conductance.	Define conductance as the reciprocal of resistance and explain its unit.	Using a calculator, determine the conductance of specific resistor values.
Watt and power.	Define power as the useful work accomplished by the electric current. Use examples of lighting a bulb, heating a toaster, operating a motor, etc.	Define electrical power.
	Show examples of light bills from local power companies.	Complete a worksheet covering a hypothetical light bill.
IV. Resistive DC Circuits		
Characteristics of series, parallel, and series-parallel circuits.	List the characteristics of a series and a parallel electric circuit.	Write the characteristics for a series and a parallel electric circuit.
	Demonstrate characteristics of basic circuits using chalkboard, overhead projector, meters, and circuit boards.	
Ohm's and Watt's laws.	Demonstrate three formulas that may be used to determine each of the four electric quantities.	Using a calculator, determine specific values of electric quantities for a given circuit.
		Hook up several experimental circuits and measure voltage, current, and resistance.
Equivalent circuits.	Demonstrate how all series, parallel and series-parallel circuits can be represented as a simple series circuit with a single load.	Calculate equivalent circuit load values for all three circuit types.
Kirchhoff's laws.	Define Kirchhoff's voltage and current laws.	Compare Kirchhoff's laws with Ohm's laws.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
V. Cells and Batteries		
Primary cells.	Discuss a variety of common primary cells.	Define a primary cell and some common uses.
	Make a primary cell with citrus fruit and coins.	Measure current and voltage of a primary cell made from different citrus fruits and coins.
		Check dry cells for local action.
	Discuss internal resistance of cells.	Measure dry cells for voltage and current output; also measure voltage drop under load conditions.
Secondary cells.	Define secondary cells and advantages of secondary cells over primary cells.	Compare the advantages of secondary cells with those of primary cells.
	Discuss a variety of common secondary cells.	Define a secondary cell and some common uses.
Charging and discharging of secondary cells.	Demonstrate the chemical steps of secondary cells with the chalkboard or overhead projector.	Explain chemical changes that occur when a secondary cell charges and discharges.
	Demonstrate the hydrometer and voltage checks on the lead acid battery and/or nickel cadmium battery.	Make a hydrometer and voltage check of a lead acid battery.
		Observe a lead acid battery under charge.
Cells connected in series and in parallel.	Demonstrate effect of connecting cells in series and in parallel with each other.	Connect cells in series and parallel and compare voltage and current readings.
Battery care.	Discuss proper care and maintenance of various types of batteries.	Properly maintain a secondary cell and/or battery.
Non-chemical cells.	Discuss fuel cells, solar cells, etc., applications, advantages, etc.	Describe non-chemical cells and discuss applications for their use.
VI. Magnetism and Electromagnetism		
Types of magnets.	Discuss permanent and electro-magnetism.	Explain how to construct an electromagnet.
Magnetic flux.	Demonstrate magnetic flux with magnet and iron filings.	Examine different materials for magnetic properties.
	Pass a small DC current through a wire and use a compass to show the presence of magnetic flux.	Compare magnets for size, shape, and strength.
Laws of magnets.	Discuss attraction of unlike poles and repulsion of like poles. Also demonstrate the left hand rule.	Determine the directon of current flow through an electromagnet using the left hand rule.
Theories of magnetism.	Explain both the molecular and domain theory of magnetism.	Compare molecular and domain theory of magnetism.
		Observe domains of a magnetized material under a microscope.
Magnetizing (through magnetic induction) and demagnetizing materials.	Demonstrate magnetizing and demagnetizing temporary and permanent materials.	
	Use a permanent magnet and nail to demonstrate magnetic induction.	Magnetize an unmagnetized material by placing an external magnetic field through it.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Magnetic shielding.	Explain reasons for shielding against unwanted magnetic induction.	
Magnetic constants and units.	Define permeability, reluctance, magnetomotive force, flux density, flux strength, as basic magnetic circuit quantities.	
VII. Basic Test Instruments		
Multimeters.	Explain the functions and proper use of a multimeter.	Describe how to properly use each function of a multimeter.
	Discuss common construction features of meters; including moving iron or solenoid type, thermal or hot wire type, iron vane type, D'Arsonval type, electrostatic type, rectifier type, etc.	Compare various meters and their movements.
	Demonstrate various meters and their characteristics; including galvanometer, voltmeter, ammeter, ohmmeter, wheatstone bridge, etc.	Practice reading analog meter scales.
		Make continuity tests upon fuses and connecting wires.
		Measure voltage and current in simple circuits.
	Demonstrate the use of shunts, multipliers and rectifiers.	Complete worksheets on meter movements, shunts, multipliers, and rectifiers.
Electronic power supplies.	Discuss regulated DC power supply used to power experimental lab circuits.	Practice adjusting the output of your power supply for specific DC voltages.
Oscilloscopes.	Discuss the operation and uses of an oscilloscope.	Measure a DC voltage with an oscilloscope.
Signal generators.	Discuss the operation and uses of an audio and an RF generator.	Describe the purpose of each control on an audio generator.
VIII. Alternating Current		
Definition of AC.	Plot sine wave.	Describe a sine wave.
	Show sine wave with the oscilloscope.	Display an AC sine wave on an oscilloscope.
	Demonstrate alternating current.	
Amplitude.	Discuss peak-to-peak, peak, rms, and average AC values.	Define P-P, P, rms, and average AC amplitudes.
	Demonstrate how to determine a P-P amplitude of a sine wave using an oscilloscope.	Measure the P-P amplitude of a sine wave with an oscilloscope.
	Demonstrate how to determine an rms amplitude with an oscilloscope and volt meter.	Measure an rms amplitude with an AC voltmeter.
		Calculate an rms amplitude of a sine wave using an oscilloscope.
Alternation.	Discuss the postive and negative alternation making up one sine wave cycle.	Adjust oscilloscope to display one cycle of an AC sine wave.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Period.	Define period.	Define period.
	Demonstrate how the period of a sine wave can be determined with an oscilloscope.	Determine the period of an AC sine wave with an oscilloscope.
Frequency.	Define frequency.	Determine the frequency of an AC sine wave with an oscilloscope.
IX. Inductance		
Induced voltage and Lenz's law.	Discuss necessary conditions for induced voltage.	Describe induced voltage as inductance.
	Explain how induced voltage is always series-opposing the voltage source due to Lenz's law.	Explain Lenz's law.
Phase angle and the henry unit.	Explain effect of magnetic field producing a voltage leading current phase angle and the henry unit of inductance.	Discuss why voltage leads current in a purely inductive AC sinusoidal circuit.
Factors determining inductance.	Discuss the relationships between number of turns, cross-sectional area of turns, permeability of the core and the length of the core upon inductance.	Calculate inductance of an inductor using its physical parameters.
Self and mutual inductance.	Explain self and mutual inductance of single and multiple inductors.	Calculate the amount of self inductance a single inductor will produce.
Types of inductors.	Demonstrate various forms of inductors.	Examine and compare several inductors.
Inductors in series and parallel connection.	Discuss effect of placing inductors in series and parallel circuit configurations.	Discuss how mutual inductance may produce undesirable effects when placing individual inductors in series or parallel configurations.
Inductive time constant circuits.	Discuss the effect of varying the values of either resistance or henrys upon time required for current to reach a maximum value in DC applications.	Calculate the value of one time constant for an RL direct current circuit.
Application of inductors.	Discuss filtering action of inductors at various frequencies.	Explain usage of inductors in various common circuits such as a radio.
X. Transformers		
The "ideal" transformer.	Explain the concept of an ideal transformer.	Discuss how actual transformers are constructed to approximate the ideal model.
Transformer losses.	Discuss copper losses, eddy currents and hysteresis of transformer cores.	Discuss how transformer cores can be constructed to minimize losses.
Transformer ratios.	Discuss turns, voltage, current, and impedance ratios of an ideal transformer.	Calculate unknown quantities using transformer ratios.
	Use oscilliscope to demonstrate the amplitude of primary and secondary voltage of various transformers.	Use an oscilloscope to compare the amplitude of primary voltage to secondary voltage.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Types of transformers.	Discuss step-up, step-down, and isolation transformers.	Determine whether a transformer is step-up, step-down, or isolation type.
	Discuss single and multi-tapped secondary transformers (the auto-transformer).	Examine and compare several transformers.
Applications of transformers.	Discuss transformer coupling and maximum power transfer.	Explain usage of transformers in various common circuits such as a radio.
XI. Capacitance		
Displacement current and stored charge.	Discuss displacement of electrons from one plate of a capacitor to the other.	Explain how displacement current charges a capacitor.
	Explain how voltage across a capacitor is always series opposing the voltage source.	
Phase angle and the Farad unit.	Explain effect of an electrostatic field producing a current leading voltage phase angle and the farad unit of capacitance.	Discuss why current leads voltage in a purely capacitive AC sinusoidal circuit.
Factors determining capacitance.	Discuss the relationship between core permittivity, area of the plate and thickness of the dielectric upon capacitance.	Calculate capacitance of a capacitor using its physical parameters.
Types of capacitors.	Discuss various dielectric materials available, also working voltage and polarization.	Examine and compare several capacitors.
Capacitors in series and parallel connection.	Discuss effect of placing capacitors in series and parallel circuit configurations.	Calculate total capacitance of several capacitors in series and parallel configurations.
Capacitive time constant circuits.	Discuss the effect of varying the values of either resistance or farads upon time required for voltage to reach a maximum value in DC applications.	Calculate the value of one time constant for an RC direct circuit.
Application of capacitors.	Discuss filtering, bypassing, waveshaping, and coupling applications of capacitors.	Explain the usage of capacitors in various common circuits such as a radio.
XII. Resistance, Inductance, and Capacitance in Sinusoidal AC Circuits		
Inductive reactance.	Discuss opposition of alternating current due to inductance; symbol XL, unit ohm.	Calculate the amount of inductive reactance produced by an inductor.
Capacitive reactance.	Discuss opposition to alternating current due to capacitance; symbol XC, unit ohm.	Calculate the amount of capacitive reactance produced by a capacitor.
Series RLC circuits.	Discuss how varying frequency of the voltage source determines the values of XL and XC and the type of equivalent circuit; series RL or RC.	Determine the equivalent series circuit type for a given series RLC circuit at a specific frequency of operation.
Parallel RLC circuits.	Discuss how varying frequency of the voltage source determines the values of XL and XC and the type of equivalent circuit; parallel RL or RC.	Determine the equivalent parallel circuit type for a given parallel RLC circuit at a specific frequency of operation.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
Phase angle between total voltage and total current in RLC circuits.	Explain leading and/or lagging phase angles of various RLC circuits.	Determine whether the circuit phase angle is leading or lagging (E leads I or E lags I).
Impedane and admittance.	Explain how to determine impedance of a series RLC circuit and the admittance of a parallel RLC circuit.	Determine the impedance of series and parallel RLC circuits.
Phasors and complex numbers.	Demonstrate series and parallel RLC circuit with appropriate voltage, current, impedance, or admittance phasors.	Determine whether a circuit is series RLC or parallel RLC by reading a phasor diagram for the circuit.
	Express electrical quantities in rectangular and polar forms.	
Power in AC circuits.	Discuss apparent, true and volt-ampere reactive power, and power factor.	Calculate the true power dissipated in an AC circuit.
Resonance.	Discuss the characteristics of series and parallel resonant circuits.	State the condition of a series and/or parallel RLC circuit at resonance.
	Discuss application of series and parallel resonant circuits.	
Filters.	Discuss high-pass, low-pass, bandpass, and bandstop filters.	Draw schematic diagrams for each filter type and explain circuit operation.
XIII. Generators/Alternators		
AC generator characteristics.	Discuss physical characteristics of AC generators to include: alternator frequency and construction.	Examine, disassemble and reassemble an alternator.
	Discuss polyphase generators and types of three-phase connections.	
DC generator characteristics.	Discuss physical characteristics of DC generators to include: series field, shunt field, compound generators, separately excited generators and generator efficiency.	Compare and contrast DC generators with the modern day alternator.
Generator control.	Explain methods of generator control.	Examine generator controls.
XIV. Electric Motors		
AC motor characteristics.	Discuss physical characteristics of AC motors to include: construction, rating and efficiency.	Examine, disassemble and reassemble various AC motors.
	Discuss the following motor types: universal motor, induction polyphase motor, split-phase induction motor, capacitor-start motor, shaded-pole motor, inductance-start motor and synchronous motor.	State appropriate uses for a specific AC motor type.
DC motor characteristics.	Discuss physical characteristics of DC motors to include: construction, rating, and efficiency.	Reverse direction of run on motors that will reverse.
	Discuss the following motor types: series field motor, shunt field motor and compound motor.	State appropriate uses for a specific DC motor type.
Electric motor controls.	Demonstrate various types of motor controls.	Examine and observe motor controls in operation.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
XV. Diodes and Rectifiers		
Semiconductor diodes.	Explain current flow through a PN junction.	Explain the difference between majority and minority charge carriers.
	Explain forward and reverse biasing of a PN junction.	With an ohmmeter, show how resistance is measured in one direction and infinite in the other direction.
	Demonstrate how to use an ohmmeter to detect a defective diode.	
Vacuum tube diodes.	Explain current flow through a vacuum tube diode.	Explain why current flows in only one direction through a vacuum tube diode.
	Explain DC polarities necessary to bias a vacuum tube diode.	
Rectifier circuits.	Discuss half- and full-wave semiconductor rectifier circuits.	Observe the output of a half-wave and full-wave rectifier with an oscilloscope.
SCR family of devices.	Discuss characteristics of thyristors; SCR, DIAC, and TRIAC devices.	State applications for an SCR.
XVI. Transistors		
Bipolar transistors.	Explain current flow through a bipolar transistor.	Use an ohmmeter to determine wheter a bipolar transistor is NPN or PNP.
	Explain forward and reverse biasing for NPN and PNP bipolar transistors.	Properly bias a bipolar transistor using two DC sources and measure emitter and collector currents.
Field-effect and unijunction transistors.	Explain conduction of field effect and unijunction transistors.	
	Discuss MOS-FET transistors.	
XVII. Vacuum Tubes		
Triodes.	Explain the operation of the control grid of a triode.	Properly bias a triode and measure plate current.
	Compare triode tubes with bipolar transistors.	
Tetrodes.	Explain the operation of the screen grid of a tetrode.	
Pentodes.	Explain the operation of the suppressor grid of the pentrode.	
XVIII. Integrated Circuits		
Large scale integration.	Discuss construction methods of an integrated circuit.	
Operational Amplifiers.	Discuss characteristics of an ideal op amp and common uses for the device.	Draw schematic diagrams for the following op amp circuits: inverting amp, summing amp, differential amp, integrator, differentiator low and high pass filter.
Logic chips.	Discuss AND, OR, NAND, and NOR gate circuits.	Show logic state of gate circuits using truth tables.
Microprocessors.	Discuss uses of the microprocessor.	

Level II
Basic Electricity-Electronics Techology
See Appendix B for Producer/Distributor Addresses

16mm Films

1. AC Motors - USNAC
2. Alternating Current - AIM
3. Amplifier Principles - USNAC
4. Basic Amplifiers - USNAC
5. Basic Circuit Symbols and Components - USNAC
6. Bell Solar Battery - ATAT
7. Bridge Rectifiers - USNAC
8. Capacitance - EBEC
9. Capacitors: DC - AC Action - USNAC
10. Cathode-Ray Oscilloscopes - AIM
11. Charles Proteus Steinmetz: The Man Who Made Lightning - UILL
12. Circuit Testing with Meters - UILL
13. Current Electricity - CENCO
14. Current Flow: What It Is - USNAC
15. DC Circuit Parameters - USNAC
16. DC Motors - USNAC
17. DC Series Resistive Circuits - USNAC
18. Electric Decision - AIM
19. Electricity for Beginners - UMO
20. Electricity: Handle with Care - UMO
21. Electricity: The Way It Works - UMO
22. Electrodynamics - TAI
23. Electromagnetic Wave - UMO
24. Electromagnets: How They Work - UMO
25. Electronics: An Introduction - BFA
26. Elements of Electrical Circuits - UMO
27. Ferromagnetic Domains - ATAT
28. Filters and Power Supplies - USNAC
29. Fundamentals of AC and DC Generators - UILL
30. How Transformers Work - MSU
31. Induced Electric Currents - UMO
32. Inductance - TAI
33. Integrated Electronics: A New Art - BELLTL
34. Introduction to Vacuum Tube Circuits - AIM
35. Magnetism - UIOWA
36. Making Electricity - UMO
37. Measurement of Current - AIM
38. Measurement of Voltage and Resistance - AIM
39. Ohm's Law - UMO
40. Oscilloscopes: Frequency and Measurement - USNAC
41. Parallel Resistive Circuits - USNAC
42. Parallel RC, RL, and RLC Circuits: Graphic Solutions - USNAC
43. Primary Cell - UILL
44. Principles of Electricity - UILL
45. Principles of the Transistor - UILL

46. RC Transients - USNAC
47. Resistors: Color Code - USNAC
48. Resonant Circuits - AIM
49. RL Transients - USNAC
50. RLC: Resistance, Inductance and Capacitance - TAI
51. Solid-State Principles - USNAC
52. Sounds Familiar - ATAT
53. Static Electricity - AIM
54. Story of the Modern Storage Battery - USDIBM
55. The Oscilloscope: What It Is and What It Does - TEK
56. The Transistor - ATAT
57. Transformers - AIM
58. Transistor Triode Characteristics - USNAC
59. Use of the Oscilloscope - USNAC
60. Uses of Resonant Sections - USNAC
61. Vacuum Tubes - UMO
62. Vacuum Tubes: Bias in Triodes - USNAC
63. Voltage Dividers - USNAC
64. When the Circuit Breaks - MTP
65. Wire Sizes and Voltage Drop - UILL
66. World of Semiconductors - UILL
67. Your Voice and the Telephone - ATAT

Filmstrips

1. Basic Electricity and Electronics: Alternating Current - BGW
2. Basic Electricity and Electronics: Reactive Circuits - BGW
3. Electricity Series No. 11330 - EBEC
4. Electricity Set No. 170050 - MGHF
5. Electricity and Magnetism Set A-6 - PSPC
6. Fusion Energy: Hope for the Future - BGW
7. How Electric Motors Start and Run - AAVIM

Slides

1. Electric Energy - IML
2. Electric Motors: Selection, Protection and Drives - IML

Transparencies

1. Alternators: Principles of Operation - FMC
2. Basic Electronics - ETI
3. Battery Operation, Construction, and Testing - FMC
4. Electric Motors: Selection, Protection, Drives - IML
5. Electricity: Sets 1 through 7 - HBC
6. Electricity and Basic Electronics - DCA
7. Transparencies Pac Set - MCKT

Videocassettes

1. Basic Electricity: AC Parallel Circuits - USNAC
2. Basic Electricity: AC Series Circuits - USNAC
3. Basic Electricity: Capacitance in AC Circuits - USNAC
4. Basic Electricity: Inductance in AC Circuits - USNAC
5. Capacitance, Physical and Electrical Characteristics and Factors Affecting Capacitance -USNAC
6. Circuit Testing with Meters and Multimeters - USNAC
7. Direct Current Motors: Theory of Operation - USNAC
8. Loaded Voltage Dividers - USNAC
9. The Junction Transistor - USNAC
10. Transistors: Triode Fundamentals - USNAC
11. Transistors: Minority Carriers - USNAC
12. Transistors: PN Junction Fundamentals - USNAC

Level III
Basic Applications of Electricity-Electronics
(Consumer Product Servicing)

Level III curriculum is for one full year and is for students who desire more advanced experience in electronics. It is recommended that students have satisfactorily completed Level II curriculum or advanced science courses.

This course will enable the student to utilize knowledge of electronic components to construct practical working models of the most common electronic circuits (power supplies, amplifiers and oscillators). Also, greater emphasis is placed upon proper usage and care of electronic test instruments (multimeter, oscilloscopes, signal generators) and developing a logical troubleshooting technique for isolating and replacing defective electronic components. Therefore, throughout the course students will have the opportunity to work on a variety of consumer electronic devices (radios, stereos, televisions, etc.) to demonstrate proficiency.

This course will also afford the student the opportunity to determine whether continued work in electronics is desirable and at which level the student should prepare (engineer, technician, technologist, salesperson, etc.). Therefore, this course in electronics offers an excellent base on which students may build vocational pursuits or plan for additional education in the field of electronics.

The numbers listed below refer to bibliographic information designated for this level. To acquire more detailed information for each number, turn to the Selected Bibliography section in this guide and match the number with the corresponding reference.

Bibliographic reference numbers: 7, 8, 17, 21, 22, 26, 28, 31, 32, 34, 35, 45, 52, 53, 56, 60, 61, 62, 63, 64, 66, 70, 71, 72, 78, 79, 80, 81, 82, 97, 98, 109, 112, 113, 115, 121, 123, 129, 132, 133, 134, 137, 138, 139, 140, 141, 142, 143, 147, 150, 151, 155, 177, 183, 184, 185, 189, 190, 192, 193, 194, 196, 197, 198, 199, 201, 202, 203, 204, 205, 206, 208, 209, 213, 214, 216, 217, 218, 223, and 224.

Behavioral Objectives For
Basic Applications For Electricity-Electronics
(Consumer Product Servicing)

Upon completion of this course of study, the student will be able to:

1. Demonstrate safe working practices and procedures with all necessary tools and equipment.
2. Demonstrate a working knowledge of passive and active electric components.
3. Construct a functioning power supply circuit.
4. Construct a functioning audio or radio frequency amplifier circuit.
5. Construct a functioning oscillator circuit.
6. Explain principles of electromagnetic radiation of radio waves.
7. Draw block diagrams of AM and FM radio receivers.
8. Explain function of all stages of superheterodyne radio receivers.
9. Troubleshoot malfunctioning radio receiver and complete repairs.
10. Explain functions of all stages of a television receiver.
11. Troubleshoot malfunctioning television receivers and complete repairs.
12. Utilize electronic skills to troubleshoot and complete repairs on other communications equipment (i.e. tape players, etc.).

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
I. Safety Practices, Basic Skills, and Career Opportunities		
Personal safety, procedures, proper use and maintenance of tools and test equipment. Reviewed as necessary during the year.	Review rules for electrical safety.	Practice shop safety rules.
	Review proper use and maintenance of all test equipment and tools.	Complete safety test on shop rules for tools and equipment.
Career opportunities.	Discuss employment opportunities.	
II. Basic Electronic Skills		
Review of symbols, schematic diagrams, and basic electrical theory.	Schematic reading review.	Practice meter reading, schematic reading.
Passive and active components.	Review basic DC and AC circuits and theorems.	Construct circuits from schematics.
		Discuss uses for passive and active electronic components.
III. Power Supplies		
Semiconductor rectifiers.	Explain power soufces. Explain rectification and types of power supplies. Demonstrate with oscilloscope the effects of filters. Explain vacuum tube, semi-conductor rectifiers and controlled rectifiers. Explain how gas diodes may regulate voltages in a power supply.	Measure voltage and current from various basic sources. Hook up half wave, full wave, and bridge rectifier and observe on oscilloscope. Experiment with and observe the effect of filters and loading on a power supply. Construct power supply section of superheterodyne receiver.
Vacuum tube rectifiers.		
Rectifiers filters regulation.		
Photo-electric power supplies.		
IV. Amplifiers		
Audio frequency amps (AF).	Discuss the following: nature of sound, positive tube parameters, feedback, inverse feedback, loading, impedance matching, and de-coupling, wide band and RF amplifiers, classes of amplification, voltage and power amplifiers, Hi-Fi and stereo amplifiers, tone controls and volume controls.	Design and assemble a multistage audio amplifier; test and observe voltage relationships, wave forms and amplification. Test differences in resistance, impedance and transformer coupling. Add audio sections to the superheterodyne receiver.
Classes of operation (biasing)		
Voltage and power amps.		
Radio frequency amps (RF).		
V. Oscillators		
L-C tank circuits.	Explain principles of oscillator circuits.	Construct a simple Harley or Colpitts oscillator circuit. Note effect of loading with direct connection of scope. Observe output on scope with loose couples probe.
Oscillator drift.	Demonstrate oscillator loading and drift with L-C tank oscillator.	
Crystal oscillators.		

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
VI. Transmitter Circuit Application		
Basic AM & FM transmitter circuits and tuning principles.	Discuss the purposes and circuits of each section of an AM transmitter.	Construct and test a low power oscillator circuit.
	Demonstrate the tuning and loading of a transmitter.	Construct, tune, and test a low power CW transmitter.
	Discuss the circuits and purposes of each section of an FM transmitter. Explain how both AM & FM systems are used in television.	Construct, tune, and test a low power radio-telephone transmitter.
VII. Electromagnetic Radiation		
Propagation, antenna, transmission lines, and impedance matching.	Discuss the radio frequency spectrum and how electromagnetic radiation takes place.	Select and safely install an outside antenna.
	Discussion of antennas: types orientation, gain, radiation patterns, dimensions, radiation resistance, harmonics.	Complete frequency to wave length conversions.
	Discussion of transmission lines: types, impedance matching, harmonic operation, standing waves, installation and safety precuations.	Compute antenna and tuned transmission line lengths. Transmission line, source, and load impedance matching.
	Illustrate antenna and transmission line computation and antenna feedpoints.	
VIII. Receiver System Application		
Radio communication principles, stages of AM and/or FM radio, detectors, oscillators, tuners, converters, transmitters, and TV circuits.	Discuss: Communications and nature of radio signals, unmodulated carrier, amplitude modulation, frequency modulation, modulation methods, types of detectors, tuners, antennas, types of oscillators. TRF and superheterodyne receivers, amateur radio and citizens band, television, teletype and facsimile.	Suggested project: Build or complete superheterodyne radio. Observe voltages, frequencies, and wave forms of a radio. Align a radio. Build a simple transmitter, try various modulation systems.
	Introduce projects made from the schematic. May be some TV repair work.	Troubleshoot, repair and align an AM and FM receiver.
	Discuss TV receiver sections: RF & converter, vertical, and horizontal sweep and sync, high voltage deflection. CTR, and composite signal.	Troubleshoot, repair and align a TV receiver.

Level III
Exploring Electricity-Electronics
See Appendix B for Producer/Distributor Addresses

16mm Films

1. ABC's of Hand Tools - ARIZSU
2. Amplitude Modulation - AIM
3. Audio Amplifiers - USNAC
4. Audio Amplifier Principles: Parts 1 and 2 - USNAC
5. Basic Principles of FM - USA
6. Basic Radio Circuitry -USNAC
7. Basic Television Terms: A Video Dictionary - PFP
8. Cathode-Ray Tube - TEK
9. Circuit Testing - UIOWA
10. Class A Audio Amplifiers - AIM
11. Class B and Push-Pull Audio Amplifiers - AIM
12. Colour Television - MGHT
13. Communications: The Wired World - HOBLEE
14. Composition of an AM Wave - USNAC
15. Design Factors in Power Supplies - AIM
16. Diode and Rectifier Circuits: Full-Wave Rectifiers - USNAC
17. Diode and Rectifier Circuits: Solid-State Principles - USNAC
18. Effects of the Ionosphere on Radio Wave Propagation - USA
19. Electricity: Principles and Safety - UARIZ
20. Electromagnetic Cathode-Ray Tube: Theory of Operation - USNAC
21. Electromagnetic Waves - EBEC
22. Electronics: Units 1 through 5, Audio Communications, A Series - AIM
23. Electronics Service Technician: The Future's Unlimited - ASTE
24. Electronic Oscillators - AIM
25. Electronic Voltage Regulators - USNAC
26. Frequency Modulation, Pt. 1: Basic Principles - USNAC
27. Genesis of the Transistor - ATAT
28. How Television Works - UEVA
29. Impedance Characteristics of Amplifiers - AIM
30. Introduction to Amplitude Modulation - USNAC
31. Introduction to Detection - USNAC
32. Introduction to Discriminators - USNAC
33. Introduction to Radio Receivers - AIM
34. Introduction to Radio Trnasmitters - AIM
35. Introduction to Video Amplifiers - AIM
36. Is a Career in Radio and Television for You - COUNFI
37. Measurement of Electricity - UARIZ
38. Mirror in the Sky - UCOLO
39. Oscillators, Amplifiers and Radios - UILL

Level III

40. Oscillators - UWF
41. Percentage of Modulation - USNAC
42. Practical TV Alignment - MGHT
43. Principles of Transistors - UILL
44. Radio Antennas: Creation and Behavior of Radio Waves - USNAC
45. Radio Antennas: Fundamentals of the Antenna - USNAC
46. Radio Receivers: Principles of Radio Receivers - USNAC
47. Radio Receiver, Principles, and Typical Circuits - UILL
48. Radio Shop Techniques - USNAC
49. Radio Transmitter Principles - UILL
50. Radio Waves - UIOWA
51. Receiving Radio Messages - UICWA
52. Receiver Alignment - USNAC
53. Receiver Troubleshooting Procedures - USNAC
54. Semiconductors: Parts 1 and 2 - BRAY
55. Series and Parallel Circuits - USNAC
56. Standing Waves on Transmission Lines - USNAC
57. Superheterodyne Receiver, The - AIM
58. Television Camera Tubes - AIM
59. Television: How It Works - UMO
60. Television Receivers: Parts 1, 2, 3, and 4 - AIM
61. The Electronic Technician - MTP
62. The Television System - MGHT
63. The Triode: Amplification - UILL
64. Transistor Configurations, The - NAPHIL
65. Transistor Amplifiers: Parts 1, 2, and 3 - AIM
66. Transmission Lines - TEK
67. Tuned Circuits - USNAC
68. Tuned Plate Oscillator - USNAC
69. Your Future in Electronics - RCA
70. Vacuum Tubes: Electron Theory and the Diode Tube - USNAC

Level III

Filmstrips

1. Alternating Current Theory: 500 Series - AEFC
2. Electronic Circuit Action Series - BMEP
3. Electronic Power Supplies - BGW
4. Television Symptom Diagnosis - BMEP
5. Television Symptom Diagnosis - HWSC
6. Transistors and Transistor Circuits: 300 Series - AEFC
7. Tubes and Tube Circuits: 100 Series - AEFC

Slides

1. Transistor Review Series - BMEP

Transparencies

1. Electricity and Basic Electronics - DCA
2. Semiconductors - ETI
3. Electricity-Electronics - BG
4. Electricity-Electronics: Series 601, 602, 603, 604 - LVES
5. Transparencies Pac Set - MCKT

Videocassettes

1. Audio Amplifier Principles, Part 1 - USNAC
2. Basic Amplifiers - USNAC
3. Frequency Modulation, Basic Principles - USNAC

Level IV
Specialized Applications of Electricity-Electronics

Level IV curriculum has been developed to better serve the needs of high-ability, low-ability and special interest students in grades nine through twelve. Many of the specialized areas included may be approached on an individualized instructional basis, giving students an opportunity to advance at their own rate with minimal supervision from the instructor. Thus, it may be possible for many students to pursue an individual interest when instruction in the traditional class setting may not be successful or even possible. (For example, on an individualized basis, a student may learn the same course content of Level II without the structure of a formal classroom setting.) Students may have the opportunity to choose a specific interest area or study as many areas as time permits during the school year.

Sections of Level IV may also be utilized by instructors to augment curriculum listed in Levels I through III or to serve as specific units an instructor may wish to introduce at an appropriate time during the school year.

The numbers listed below refer to bibliographic information designated for this level. To acquire more detailed information for each number, turn to the Selected Bibliography section in this guide and match the number with the corresponding reference.

Bibliographic reference numbers: 1, 2, 3, 4, 5, 7, 8, 11, 12, 13, 14, 15, 17, 18, 24, 25, 27, 28, 30, 31, 32, 35, 36, 37, 40, 41, 42, 43, 44, 51, 52, 53, 56, 57, 60, 62, 63, 64, 65, 67, 68, 72, 73, 74, 76, 79, 81, 83, 84, 85, 86, 87, 89, 90, 91, 94, 95, 96, 97, 98, 100, 101, 102, 103, 105, 106, 107, 108, 109, 110, 111, 114, 115, 118, 120, 123, 125, 126, 127, 128, 129, 131, 141, 148, 149, 151, 153, 155, 158, 159, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 178, 179, 180, 181, 182, 183, 184, 186, 188.

Behavioral Objectives For Specialized Applications of Electricity-Electronics

Upon completion of this course of study, the student will be able to:

1. Demonstrate safe working practices and procedures with all necessary tools and equipment.
2. Demonstrate acceptable expertise in one chosen electrical and/or electronic speciality, to include:
    a. Proper attitudes toward fellow workers and toward maintenance of shop facilities.
    b. Proficiency and confidence in the use of electrical and electronic test equipment.
    c. Proficiency in setting up, checking, operating, testing, and troubleshooting electrical and/or electronic circuitry as used by industry.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
I. Safety Practices and Basic Skills		
Shop safety and use of tools and equipment.	Discuss shop safety and proper care and use of tools and test instruments (review as necessary through the year.)	Practice shop safety. Successfully pass tests on shop safety and care and use of test instruments.
Basic electrical skills.	Discuss basic electrical principles and concepts or use individualized course of study such as "Basic Electronics I" (IML).	Pass exams covering Level II and Level III curriculum.
II. Employment and Educational Opportunities		
Immediate employment versus advanced education in the field of electronics. Salary versus opportunity.	Discuss enlarged earning power in electronics field with advanced education.	Survey Missouri and U.S. Employment Service Publications of salaries and job opportunities in electronics.
III. Electrical Wiring-Residential		
Electrical codes.	Discuss the National Electrical Code and local code authorities for wiring installations.	Interpret appropriate portions of the NEC concerning residential wiring installations.
Wiring devices and symbols.	Discuss various wiring devices and draw cable layout and wiring diagram symbols.	Draw cable layout and wiring diagram symbols for all common wiring devices.
Electrical installation.	Discuss procedures or use individualized course of study such as "Electrical Installation Work" (IML).	Draw cable layouts and wiring diagrams for all electrical circuits to be installed.
Commercial and industrial wiring.	Discuss appropriate sections of NEC covering commercial and industrial installations.	Interpret appropriate portions of the NEC concerning commercial and industrial wiring installations.
IV. Appliance Servicing		
Appliance types.	Discuss small and large heating and motor-type appliances.	Explain operating principles of small and/or large heating and motor operated appliances.
Servicing techniques.	Discuss servicing techniques for each type of appliance or utilize individualized course of study such as "Home Appliance Servicing" (IML).	Determine problem and correct malfunctioning appliances.
V. Automotive Electricity		
Electrical systems: cranking, ignition, charging, lighting, emission, fuel injection, power windows, and seats.	Discuss automotive electrical systems or utilize individualized course of study such as "Auto Mechanics Vol. 2" (IML).	Describe the main automotive electrical systems.

CONTENTS: What the Student Should Know	TEACHER ACTIVITIES: Discussion/Demonstration Topics	STUDENT ACTIVITIES: What The Student Should Be Able To Do.
VI. Electrical Power Technology		
Transformers.	Discuss single phase and polyphase transformers and the delta and wye sources.	Discuss phasing of wye and delta single and three-phase sources.
Motors.	Discuss single phase and polyphase motors.	Explain operation of a three-phase electric motor.
Thyristor family of devices.	Discuss Thyratron, SCR, DIAC, TRIAC, gas-filled and mercury-pooled rectifiers and polyphase rectifier circuits.	Explain operation of an SCR as a means of controlling an electric motor.
Control systems.	Discuss principles of servo and sequential timing control systems.	Discuss mechanical relay-type control systems.
Digital control.	Discuss electronic means of motor control using programable controllers.	Discuss electronic means of motor control.
VII. Microwave Systems		
Principles of operation and application of basic circuits for communication and radar.	Discuss comparisons between microwave and lower frequency radiations.	Calculate wavelength of microwave frequencies.
	Discuss skin effect, wave guides, coaxial cables and cavity resonators.	Construct UHF oscillator, measure power output and wavelength.
	Discuss and demonstrate microwave generators, receivers and antennas (launchers).	Construct UHF receiver and directional antenna.
VIII. Broadcast/Mass Communications		
Oscillators and transmitters.	Discuss various oscillator circuits used in broadcast transmitter circuits.	Construct RF oscillator and frequency doubler circuit.
	Discuss high and low level modulation transmitters and basic AM and FM configurations.	Construct an FM broadcast transmitter circuit.
Station equipment.	Discuss equipment used in commercial broadcast station (radio and/or television).	Explain function of all controls on a typical broadcast board.
Station duties and responsibilities.	Discuss FCC requirements and station rules and regulations.	Successfully pass exams covering FCC rules and regulations.
IX. Digital Electronics		
Logic gate circuits.	Discuss AND, OR, NAND, and NOR logic gate circuits.	Draw symbols for each logic gate circuit.
Boolean algebra.	Discuss base 2 system used for digital computers.	Count to ten in base 2.
Truth tables.	Discuss simplifying gate circuit configurations with truth tables.	Construct a truth table for each digital logic gate circuit.
Multivibrators, counters, and registers.	Discuss the multivibrator counter and register circuit configurations.	Explain the function of multivibrators, counters, and registors.
X. Basic Computer Systems		
Microprocessors.	Discuss uses for the microprocessor.	Discuss how microprocessors are used by industry.
	Discuss programming of a microprocessor with the aid of an appropriate trainer such as the HEATHKIT system.	Program microprocessors on an appropriate trainer.

Level IV
Specialized Applications of Electricity-Electronics
See Appendix B for Producer/Distributor Addresses

16mm Films

1. At Home with Switches - PRISM
2. Automatic Machines - MIT
3. Automation in Air Traffic Control - USN
4. Basic Computer Terms - PFP
5. By the Numbers - IBM
6. Care and Feeding of Microphones - USNAC
7. Careers: Communications - DOUBLE
8. Cavity Resonators - USNAC
9. Circuit Boards - TEK
10. Coaxial and Microwave Miracles - UCOLO
11. Computers at Work - GE
12. Control Transformer - USNAC
13. Definition and Analysis of Alternating Current - USNAC
14. Designs in Energy - UMO
15. Digital Computer Techniques: Computer Logic - USNAC
16. Direct Current Controllers - USNAC
17. Direct Current Generators: Theory of Operation - USNAC
18. Direct Current Motors: Theory of Operation - USNAC
19. Double Input Mixers - USNAC
20. Electric Power Generation in Space - NASA
21. Electric Propulsion - NASA
22. Electrical Circuit Faults - USNAC
23. Electrical Wiring with Aluminum - AIM
24. Electricity: Basic Wiring - UEVA
25. Electricity: Distribution - IU
26. Electronic Computers and Applied Mathematics - UCOLO
27. Environmental Factors Affecting Reliability of Electronic Equipment - USNAC
28. Gas Tubes - USNAC
29. IBM Control Systems at Work - IBM
30. Installing Conduit - USNAC
31. Instrument Assembly and Production Flow - TEK
32. Integrated Electronics: A New Art - BELLTL
33. Introduction to Microelectronic Integrated Circuits - USNAC
34. Introduction to Multivibrators - USNAC
35. Introduction to Synchros - USNAC
36. Klystrons - USNAC
37. Logic Element Circuits - USNAC
38. Machines That Think - AEC
39. Magnetron - USNAC
40. Memory Devices - UARIZ
41. Modern Heat Treating Methods - LNCO
42. Monostable Mulitvibrators - AIM
43. Multivibrators - AIM
44. Nuclear Power for Space: Snap 9A - AEC
45. Oscilloscopes and Transducers - TEK

46. Pax Atomis: Snap-7 - AEC
47. Power for the Moonship - AEC
48. Prescan: An/SpS42 - HUAC
49. Printed Circuit Story - BRAY
50. Proper Handling of Cathode-Ray Tubes - TEK
51. Pulse Counting Circuits - AIM
52. Radar and TV - EBEC
53. Radioisotope Application in Industry - AEC
54. Relays and Their Applications - AIM
55. Safety Precautions for Electronic Personnel - UILL
56. Scatter Radar - NBOS
57. Skylab and the Sun - USNAC
58. Snapshot - AEC
59. Solar Energy: Unlimited Power - UMO
60. Solving the Unbalanced Bridge - TEK
61. Tektronics and the World of Measurement - TEK
62. The Atom in Industry - AEC
63. The Control Revolution - NETFS
64. The Electrician - UMO
65. The Information Machine - IBM
66. The New Giant - HUAC
67. The Principles of the Gas Filled Tube - UILL
68. The Story of a Value - RMCO
69. Transformers: Lab Demo - UMO
70. Transformers: Parts 1 and 2 - AIM
71. Transistors: Switching - USN
72. Traveling Wave Tube - USNAC
73. Troubleshooting Electric Circuits - USNAC
74. Varidyne AC Controlled Speed Systems - USEM
75. Waveguides - USNAC
76. Wire Sizes and Voltage Drop - USNAC

Filmstrips

1. Automotive Electrical Components - BGW
2. Automotive Pollution Control - BGW
3. CAD: Computer Aided Design Explained - BGW
4. Cold Cathode Tubes - NTEA
5. Delcotron Generator and a New Charging Circuit - GMDR
6. Digital Electronics Explained - BGW
7. Digital Electronics Explained II - BGW
8. Electric Propulsion - NASA
9. Electrical House Wiring - SED
10. Electrical House Wiring Explained - BGW
11. Electrical Wiring - MCKT
12. Electrical Wiring - AAVIM
13. Electronic Ignition Explained - BGW

14. Electronic Ignition Systems - MCKT
15. Photo-Electric Emission - NTEA
16. Regulation and the Charging Circuit - GMDR
17. Residential Electrical Wiring: Planning and Roughing In - BGW
18. Residential Electrical Wiring: Finishing the Installation - BGW
19. Residential Electrical Wiring: Low Voltage and Special Circuits -BGW
20. Rotating Machinery Explained: Direct Current Motors - BGW
21. Rotating Machinery Explained: Single-Phase AC Motors - BGW
22. Rotating Machinery Explained: Three-Phase AC Motors - BGW
23. Science, Technology and Society - AISI
24. Space Navigation - NASA
25. The Alternator Explained - BGW
26. The Charging System - BGW
27. The Cranking Circuit and How It Works - GMDR
28. The Ignition System - BGW
29. The Ignitron - NTEA
30. The Thyratron - NTEA
31. Transistorized Multivibrator #320 - AEFC
32. Twenty Thousand Volts Under the Hood - GMDR
33. Vectors No. 1 S(80881) - EBEC

Slides

1. Electric Energy - IML
2. Electric Motors: Selection, Protection, Drives - IML
3. Electric Wiring - IML
4. How Electric Motors Start and Run - IML
5. Maintaining the Lighting and Wiring System - IML
6. Understanding Electricity and Electrical Terms - IML

Transparencies

1. Electric Motors: Selection, Protection, Drives - IML
2. Maintaining the Lighting and Wiring System - IML
3. Residential Wiring - IML

Videocassettes

1. Cable Surface Wiring - USNAC
2. Electrical Circuit Faults - USNAC
3. Electrical Work: Electrical Machinery - A Series - USNAC
4. Electrical Work: Wiring - A Series - USNAC
5. High Frequency Wave Propogation - USNAC
6. Installing Conduit - USNAC
7. Installing Surface Metal Raceway - USNAC
8. Joining Solid Conductors - USNAC
9. Porcelain Protected Surface Wiring - USNAC

10. Power Bending Conduit - USNAC
11. Preparing Old Buildings for Wiring - USNAC
12. Repulsion Motor Principles - USNAC
13. Rotating Magnetic Fields - USNAC
14. Roughing-in Nonmetallic Sheathed Cable - USNAC
15. Single-Phase and Polyphase Circuits - USNAC
16. Soldering Lugs and Splicing Stranded Conductors - USNAC
17. Split-Phase Motor Principles - USNAC
18. Squirrel-Cage Motor Principles - USNAC
19. Three-Wire Service Entrance - USNAC
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Appendix A: Publisher Addresses

American Technical Society, 848 E. 58th St., Chicago, IL 60637

Bobbs-Merrill Educational Publishing, 4300 W. 62nd St., P.O. Box 7080, Indianapolis, IN 46206

Breton Publishers: A Division of Wadsworth, Inc., 20 Providence St., Boston, MA 12116

Charles A. Bennett Co., Inc., 809 W. Detweiller Dr., Peoria, IL 61615

Delmar Publishers, 50 Wolf Rd., Albany, NY 12205

Duxbury Press: A Division of Wadsworth, Inc., North Scituate, MA 02060

Glencoe Publishing Co., Inc., 17337 Ventura Blvd., Encino, CA 91316

Goodheart-Willcox Co., 123 W. Taft Dr., South Holland, IL 60473

Hayden Book Co., Inc., Rochelle Park, NJ 07662

Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, NY 10017

Instructional Materials Laboratory, Univeristy of Missouri-Columbia, 10 Industrial Education Building, Columbia, MO 65211

John Wiley & Sons, Inc., 605 Third Ave., New York, NY 10158

MacMillan Publishing Co., Inc., 866 Third Ave., New York, NY 10022

McGraw-Hill Book Co, 13955 Manchester Rd., Manchester MO 63011

McKnight Publishing Co., Box 2854, Bloomington, IL 61701

North American Publishing Co., 401 N. Broad St., Philadelphia, PA 19108

Prentice-Hall, Educational Book Division, Englewood Cliffs, NJ 07632

Reston Publishing Co., Inc., Box 547, Reston, VA 22090

W. A. Benjamin, Inc., 2727 Sand Hill Rd., Menlo Park, CA 94025

Appendix B: Audio-Visual Producer/Distributer Addresses

AAVIM	American Association for Vocational Instructional Material, 120 Engineering Center, Athens, GA 30602
ADCP	Admiral Corporation, 3800 W. Courtland St., Chicago, IL 60647
AEC	United States Atomic Energy Commission, P.O. Box 62, Oak Ridge, TN 37830
AEFC	Animated Electronic Films, P.O. Box 2036, Eads Station, Arlington, VA 22202
AIM	Associated Instructional Materials, 600 Madison Ave., New York, NY 10022
AISI	American Iron and Steel Institute, Teaching Aids Distribution Center, Bedford Hills, NY 10507
ALLISC	Allis Chalmers Mfg. Co., Milwaukee, WI 53201
ARIZSU	Arizona State University, Audio-Visual Center, Tempe, AZ 85281
ASTF	Association-Sterling Films, 866 3rd Ave., New York, NY 10022
ATAT	American Telephone and Telegraph Co., Information Dept., 195 Broadway, Room 07-1106, New York, NY 10007
BELLTL	Bell Telephone Labs., Inc., Mountain Ave., Murray Hill, NJ 07971
BFA	BFA Educational Media, 2211 Michigan Ave., P.O. Box 1795, Santa Monica, CA 90406
BG	Brodhead-Garrett, 4560 E. 71st St., Cleveland, OH 44105
BGW	Bergwall Productions, Inc., 839 Stewart Ave., P.O. Box 238, Garden City, NY 11530
BMEP	Bobbs-Merrill Educational Publishing, 4300 W. 62nd St., P.O. Box 7080, Indianapolis, IN 46206
BRAY	Bray Studios, Inc., 630 9th Ave., New York, NY 10036
BYU	Brigham Young University, Audio-Visual Center, Provo, UT 84602
CENCO	Educational Films, 2600 South Kostner Ave., Chicago, IL 60623
CORF	Coronet Instructional Films, 66 E. South Water St., Chicago, IL 60601
COUNFI	Counselor Films, Inc., 2100 Locust St., Philadelphia, PA 19103
DCA	DCA Educational Products, Inc., 4865 Stenton Ave., Philadelphia, PA 19144
DOUBLE	Doubleday Multimedia, 1371 Reynolds Ave., Santa Ana, CA 92705
EBEC	Encyclopedia Britannica Educational Corp., 425 N. Michigan Ave., Chicago, IL 60611
ETI	Educational Technologies, Inc., 3546 Dakota Ave., Minneapolis, MN 55416
FMC	Ford Motor Company, Service Training, Dearborn, MI 48430
GEEF	General Electric Educational Films, Audio-Visual Communications, Large Lamp Dept., #482 Nela Park, Cleveland, OH 44112
GMDR	Delco-Remy Division, General Motors Corp., Technical Literature Section, Anderson, IN 46011
HBC	Hayden Book Co., Inc., 116 W. 14th St., New York, NY 10011
HOBLEE	Hobel-Letterman Productions, Toronto, Canada
HUAC	Hughes Aircraft Corp., 500 Superior Ave., Newport Beach, CA 92660
HWSC	Howard W. Sams & Co., Inc., 4300 W. 62nd St., Indianapolis, IN 46268
IBM	International Business Machines, 301 E. Armour, Kansas City, MO 64111
IML	Instructional Materials Laboratory, University of Missouri - Columbia, 10 Industrial Education Bldg., Columbia, MO 65211

Appendix B: Audio-Visual Producer/Distributer Addresses (cont'd)

IU	Indiana University, Audio-Visual Center, Bloomington, IN 47401
LNCO	Leeds and Northrop Co., Rockland and Stenton Ave., Philadelphia, PA 19144
LVES	Lab Volt Educational Systems, Buck Engineering Co., Inc., Farmingdale, NJ 07727
MCKT	McKnight Publishing Co., Box 2854, Bloomington, IL 61701
MGHF	McGraw-Hill Film Division, 300 W. 42nd St., New York, NY 10036
MGHT	McGraw-Hill Films, 110 15th St., Del Mar CA 92014
MIT	Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139
MSU	Michigan State University, Instructional Media Center, East Lansing, MI 48824
MTP	Modern Talking Picture Service, 2323 New Hyde Park, New Hyde Park, NY 11040
NAPHIL	North American Phillips Co., Inc., 100 E. 42nd St., New York, NY 10017
NASA	George C. Marshall Space Flight Center, Public Affairs Office, Huntsville, AL 35812
NBOS	National Bureau of Standards, United States Dept. of Commerce, Clearing House, Springfield, VA 22151
NETFS	NET Film Service, Audio-Visual Center, Indiana University, Bloomington, IN 47401
NTEA	Norelco Training and Educational Aids, North American Phillips Co., Inc., Professional Products Division, 100 E.42nd St., New York, NY 10017
PFP	Pyramid Films, P.O. Box 1048, Santa Monica, CA 90406
PRISM	Prism Productions, 531 Dawson Dr., Camarillo, CA 93010
PSPC	Popular Science Publishing Co., Inc., Audio-Visual Division, 1355 Lexington Ave., New York, NY 10017
PUAVC	Purdue University, Audio-Visual Center, Room 54 Stew, Lafayette, IN 47907
RCA	Radio Corporation of America, RCA Educational Services, RCA Service Co., Camden, NJ 08108
RMCO	Rockwell Manufacturing Co., Power Tool Division, Rockwell Bldg., Pittsburg, PA 15208
SED	Scott Educational Division, Holyoke, MA 01040
SF	Sterling Educational Films, 241 E. 34th St., New York, NY 10016
TAI	Teaching Aids Incorporated, P.O. Box 3527, Long Beach, CA 90801
TEK	Tektronics Inc., Box 500, Beaverton, OR 97005
UARIZ	University of Arizona, Audio-Visual Center, Tucson, AZ 85721
UEVA	Universal Education and Visual Arts, 100 Universal City Plaza, Universal City, CA 91608
UCOLO	University of Colorado, Audio-Visual Center, Boulder, CO 80309
UILL	University of Illinois, Visual Aids Services, 1325 S. Oak, Champaign, IL 61820
UIOWA	University of Iowa, Audio-Visual Center, c-5 E. Hall, Iowa City, IA 52240
UMICH	University of Michigan, Audio-Visual Center, 416 4th St., Ann Arbor, MI 48103
UMO	University of Missouri, Academic Support Center, Columbia, MO 65211
USA	Public Information Officer, United States Army, Fort Huachuca, AZ 85613
USDIBM	United States Dept. of Interior Bureau of Mines, Graphic Services Section, 4800 Forbes Ave., Pittsburg, PA 15213
USEM	United States Electrical Motors, Division of Emerson Electric Co., Old Gate Lane, Milford, CT 06460

Appendix B: Audio-Visual Producer/Distributer Addresses (cont'd)

USN	United States Navy Dept., Office of Information, Pentagon Bldg., Washington, DC 20004
USNAC	United States National Audio Visual Center, General Services Administration, Washington, DC 20409
USOE	United States Office of Education, Dept. of Health, Education and Welfare, 330 Independence Ave. SW, Washington, DC 20201
UWF	United World Films, 221 Park Ave. South, New York, NY 10003
WEC	Westinghouse Electric Corp., Visual Communications Dept., Gateway Center, Westinghouse Bldg., Pittsburg, PA 15222

Appendix C: Film Directories

Educators Guide to Free Films, Educators Progressive Service, Randolph, WI 53956

Film Catalog, University of Missouri, Academic Support Center, Columbia, MO 65211

Guide to Military: Loan Film, Serina Press, 70 Kennedy St., Alexandria, VA 22305

Guide to Government: Loan Film, Serina Press, 70 Kennedy St., Alexandria, VA 22305

Index to 16mm Educational Films, McGraw-Hill Book Co., New York, NY 10023

National Information Center for Educational Media, University of Southern California, University Park, Los Angeles, CA 90007

Appendix D: Electronics Suppliers

American Design Components, 39 Lispenard St., New York, NY 10013
Brodhead-Garrett Company, 4560 E. 71st St., Cleveland, OH 44105
Cornell-Dubilier Electronic Corp., 100 St. Francois St., Suite 209, Florissant, MO 63031
Dynascan Corp., 6460 W. Cortland St., Chicago, IL 60635
Educational Technologies Inc., 3546 Dakota Ave., Minneapolis, MN 55416
E & L Instruments Inc., 61 First St., Derby, CT 06418
ETCO Electronics, North Country Shopping Center, Rt. 9 North, Plattsburg, NY 12901
Electronics Kits Supply Co., 1261 S. Boyle Ave., Los Angeles, CA 90054
Electronic Tool Co., Inc., 101 Castleton St., Pleasantville, NY 10570
Electronic Supply, 4100 Main St., Kansas City, MO 64111
Fordham Radio, 260 Motor Parkway, Hauppauge, NY 11788
Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043
Graymark, P.O. Box 17359, Irvine, CA 92713
Heath Company, Benton Harbor, MI 49022
Hitachi Denshi American, Ltd., 175 Crossways Park West, Woodbury, NY 11797
Industrial Arts Supply Co., 5724 W. 36th St., Minneapolis, MN 55416
Jameco Electronics, 1021 Howard Ave., San Carlos, CA 94070
Kelvin Electronics, Inc., P.O. Box 8, 1900 New Highway, Farmingdale, NY 11735
Modern School Supplies, Inc., P.O. Box 958, Hartford, CT 06101
Mouser Electronics, P.O. Box C, Lakeside, CA 92040
Newark Electronics, 710 Main St., Blue Springs, MO 64015
North American Soar Corp., 1126 Cornell Ave., Cherry Hill, NJ 08002
Olson Electronics, 260 S. Forge St., Akron, OH 44327
Radio Shack, 500 One Tandy Center, Fort Worth, TX 76102
SATCO, 924 S. 19th Ave., Minneapolis, MN 55404
Science Electronics, 1085 Commonwealth Ave., Boston, MA 02215
Semiconductor Specialists, Inc., 3805 N. Oak Trafficway, Kansas City, MO 64116
Show-Me Electronics-Missouri Cable Co., Inc., 107 N. 7th St., Columbia, MO 65201
Tektronics, Inc., P.O. Box 500, Beaverton, OR 97077
Walters Electronics & Radio Supply, Inc., 3627-35 Main St., Kansas City, MO 64111

Appendix E: Teaching Systems

Brodhead-Garrett Electricity-Electronic Learning Units, 4560 E. 71st St., Cleveland, OH 44105

Degem Systems, 910 W. 12th Ave., Pompano Beach, FA 33060

Dependable Educational Programs Co., Rt 5 Box 136, Pittsburg, KS 66762

DeVry Industries, Inc., Educational Electronics Training Systems, 4141 W. Beloont Ave., Chicago, IL 60641

Educational Technologies, Inc., 3546 Dakota Ave., Minneapolis, MN 55416

Edu-Tech, P.O. Box 2499, Anderson, IN 46011

Electronic Aids, Inc., 6101 Falls Rd., Baltimore, MD 21209

Electronic Kits Supply Co., 1261 S. Boyle Ave., Los Angeles, CA 90054

Electronics Training Aids, Inc., 308 S. Hindry Ave., Englewood, CA 90301

Energy Concepts, Inc., Chicago, IL 60618

Heath/Malmstadt-Enke Lab and Systems, Benton Harbor, MI 49022

Hickok Teaching Systems, Inc., Two Wheeling Ave., Woburn, MA 01801

Lab Volt Educational Systems, Buck Engineering Co., Inc., Farmingdale, NJ 07727

McKnight's Instructional Programs in Electricity and Electronics, McKnight and McKnight Publishing Co., Bloomington, IL 61701

Philco Technical Republic Division, P.O. Box 10, 51 S. Pennsylvania Ave., Ft. Washington, PA 19034

RCA Electronic Trainers, RCA Service Co., A Division of Radio Corporation of America, Camden, NJ 08101

Simpson Electrical and Electronics Teaching Systems, 5200 W. Kinzie St., Chicago, IL 60644

Appendix F: Suggested Tool List

Electricity-Electronics

Tools and Equipment	Levels I and II	Quantity	Levels III and IV	Quantity
I. Small Tools and Equipment				
Alignment tool (set)	X	2	X	2
Bit, screwdriver (set) square tang, 1/4", 5/16", 3/8", 1/2"	X	1	X	1
Brace, ratchet (10")	X	1	X	1
Brush, bench	X	4	X	4
Coil winder	X	1	X	1
Compass	X	6		
Countersink,* high speed steel 1/4" shank, 1/2" size	X	1	X	1
Die, letter (set) (3/16")*	X	1	X	1
Die, number (set) (3/16")*	X	1	X	1
Divider, wing (6")	X	1	X	1
Drill, electric portable	X	1	X	1
Drill, hand (1/4")	X	1	X	1
Drill stand, fractional (1/16" - 1/2" by 64ths)	X	1	X	1
Drill, twist, straight shank (fractional set) high speed steel, (1/16" - 1/2" by 64ths)	X	1	X	1
Extension cord 25', heavy duty, grounded	X	2	X	2
Files (see specifications for listing)				
6", mill (flat), second cut	X	4	X	4
6", half-round, second cut	X	4	X	4
File card and brush*	X	6	X	6
File, jeweler's (set) assorted shapes, 4" - 6"	X	1	X	1
File, needle (set) set of 12 - 5-1/2" L	X	1	X	1
Gauge, thickness* (feeler) minimum 6 leaf, 1/2" x 2-1/2" x .0015"-.015"	X	1	X	1
Gauge, wire, and sheet metal (American)* sizes 0-36	X	2	X	1

*Items which are helpful but are not necessary for a beginning program.

Appendix F: Suggested Tool List (cont'd)

Electricity-Electronics

Tools and Equipment	Levels I and II	Quantity	Levels III and IV	Quantity
Goggles (spectacles), clear observation	X	12	X	12
Hammer, ball peen (12 oz.)	X	1	X	1
Hammer, claw (16 oz.)	X	1	X	6
Hydrometer	X	1	X	1
Knife, electrician's	X	6	X	6
Label maker*	X	1	X	1
Magnet, bar minimum size 1/4" x 1/2" x 3".	X	24	X	24
Nibbler, hand operated capacity 18" steel	X	2	X	2
Oiler, bench 1/2 pint size, 5" steel spout	X	1	X	1
Oilstone, cokmbination, India course and fine grits. 8" x 2" x 1"	X	2	X	2
Pliers, combination (6")	X	6	X	6
Pliers, duckbill (8")* Insulated	X	6	X	6
Pliers, diagonal cutting (6") Insulated	X	12	X	12
Pliers, needle nose (6") Insulated	X	24	X	24
Pliers, side-cutting (6") Insulated	X	12	X	12
Pliers, vise-grip wrench (7")	X	3	X	3
Press, drill* 15" cap. variable speed, number 2 Morse Tap in spindle, Model 1 2 HP, Magnetic switch	X	1	X	1
Punch, center (set)* 4" L, 1/16"-1/2" by 32nds	X	2	X	2
Punch, center automatic	X	1	X	1
Punch, chassis (round set) 2 piece dies, 7/8", 3/4", 1", 1-1/8"	X	1	X	1

*Items which are helpful but are not necessary for a beginning program.

Appendix F: Suggested Tool List (cont'd)

Electricity-Electronics

Tools and Equipment	Levels I and II	Quantity	Levels III and IV	Quantity
Punch, chassis (square set) 2 piece dies 1/2", 3/4", 1"	X	1	X	1
Punch, pin (set)* 4" L, 1/16"-1/2" by 32nds	X	2	X	2
Reamer, electrician's hand 1/8" tip, tapered, 5" L	X	1	X	1
Rivet tool (pop rivet tool)	X	1	X	1
Rule, steel (12") graduated to 1/16"	X	6	X	6
Rule, mechanical	X	6	X	6
Saw, hack (hand) adjustable to receive 9" to 12" blade	X	1	X	1
Scissors (8")	X	1	X	1
Screwdriver, insulated (set) regular blades, 3/16" by 9/32" with 4", 6", and 8" shafts	X	1	X	1
Screwdriver, Phillips (set) set with points #1, #2, #3	X	1	X	1
Screwdriver, retaining type 3/16" blade	X	2	X	2
Shield, face	X	6	X	6
Snips, tinner's, straight (#8)	X	1	X	1
Soldering aid	X	12	X	12
Soldering, copper, electric (60W) 1/4" copper tip	X	1		
Soldering, copper, electric pencil (30W) 7" slim handle	X	6	X	6
Soldering gun, electric dual heat, 240-325W, spot light	X	12	X	12
Square, combination 12" rule	X	3	X	3

*Items which are helpful but are not necessary for a beginning program.

Appendix F: Suggested Tool List (cont'd)

Electricity-Electronics

Tools and Equipment	Levels I and II	Quantity	Levels III and IV	Quantity
Tap and die (set) sizes 6-32, 8-32, 10-24, 12-24, and 1/4"-20	X	1	X	1
Vise combination (size 2")	X	1	X	1
Wire stripper, adjustable	X	6	X	6
Wrench, adjustable end (6")	X	4	X	4
Wrench, Allen key (hex) (set) #1-1/2, #12	X	2	X	2
Wrench, nutdriver (set) set of 8 drivers, sizes 3/6", 1/4", 9/32", 5/16", 11/32", 3/8", 7/16", 1/2"	X	12	X	12
Wrench, open end (set) sizes 1/4"-1"	X	1	X	1
Wrench, socket (3/8" drive) (set) 10 piece set, 7 standard sockets, sizes 3/8"-3/4" by 16ths	X	1	X	1
II. Power Supply				
Power supply, variable output 0-20V AC and DC at 10 amperes 0-40V AC and DC	X	12	X	12
Power supply, variable output, filtered 0-300V DC at 100 ma.	X	6	X	6
Signal generator	X	6	X	6
III. Test and Specialized Equipment				
Capacitor substitution box 100 mmf.-.111 mmd., 350WVDC	X	1	X	1
Oscilloscope (5" screen)	X	6	X	6
Resistance substitution box	X	1	X	1
Signal tracer	X	2	X	2
Tester, transistor	X	1	X	1

*Items which are helpful but are not necessary for a beginning program.

Appendix F: Suggested Tool List (cont'd)

Electricity-Electronics

Tools and Equipment	Levels I and II	Quantity	Levels III and IV	Quantity
Tester, tube	X	1	X	1
Digital Logic Trainer*	X	1	X	1
Microprocessor Trainer*	X	1	X	1
Frequency Counter*	X	1	X	1
Logic Probe*	X	1	X	1
Four-trace Oscilloscope*	X	1	X	1
Microcomputer System*	X	1	X	1
Industrial Electronics Trainer*	X	1	X	1
Electrical Wiring Modules and Wiring Devices*	X	1	X	1
IV. Metering Equipment				
Meter, Ammeter (AC) range 0-25 amps.	X	1	X	1
Meter, galvanometer 500-0-500 micro amperes			X	1
Meter, grip dip 400 KC 250 MC			X	1
Meter, Volt-ohm (multi-range)	X	12	X	12
Meter, VTVM, latest design	X	3	X	6
Electronic switch			X	6
Field effect multimeter			X	1
TV sweep and marker generator			X	1
DC bias supply			X	1
Color bar generator			X	1
Vectorscope			X	1
V. General Furnishings				
Bench, eight student laboratory work center	X	3	X	3

*Items which are helpful but are not necessary for a beginning program.

Appendix F: Suggested Tool List (cont'd)

Electricity-Electronics

Tools and Equipment	Levels I and II	Quantity	Levels III and IV	Quantity
Bench, electric demonstration 6' x 30" cabinet storage, 0-120V AC and DC outlets			X	1
Bookcase approximate 60" H x 10-12" D x 72" L, 3 adjustable shelves, wood or metal	X	1	X	1
Cabinet, filing 4 drawer, 52" H x 15" W x 28-1/2" D	X	1	X	1
Cabinet, instrument storage 30" W x 18" D x 72" H, with adjustable shelves and lock	X	2	X	2
Cabinet, parts storage metal, 100 drawers	X	1	X	1
Cabinet, tool storage approximate 62" W x 22" D x 84" H	X	1	X	1
Chair, teacher's welded steel construction, swivel, with casters	X	1	X	1
Desk, teacher's approx. 42" x 30" x 29" welded steel construction	X	1	X	1
Fire blanket	X	1	X	1
Fire extinguisher	X	3	X	3
First aid kit	X	1	X	1
Pencil sharpener, standard	X	1	X	1
Projector,* filmstrip (35mm) and slide (2" x 2")	X	1	X	1
Projector,* motion picture, sound	X	1	X	1
Projector, overhead	X	1	X	1
Screen, projection 60" x 60"	X	1	X	1
Table, overhead projector portable, 26" high	X	1	X	1
VCR and monitor*				

*Items which are helpful but are not necessary for a beginning program.

Appendix G: Glossary of Electrical and Electronic Terms

Active Component - vacuum tubes, transistors, or integrated circuits capable of controlling voltage or current to produce gain or switching action.

Admittance - the reciprocal of impedance. A measure of how easily current flows through an impedance. (Symbol Y, unit Mho or Siemen.)

Alternation - one-half of one complete sinusoidal cycle, either positive or negative.

Ammeter - a device to measure electrical current, either DC or AC.

Ampere - the unit of electrical current. One ampere is equal to 6.28×10^{18} charge carriers.

Amplifier - an electronic circuit which increases the amplitude of an AC signal voltage, current and/or power.

Analog Meter - a scaled meter for measuring voltage, current and/or resistance.

Apparent Power - that power delivered to the loads of a circuit from an AC voltage source, but is not always the power dissipated by the loads.

Audio Frequencies - commonly expressed as a range of audible frequencies from 20 HZ through 20 KHZ.

Autotransformer - a transformer with primary and secondary windings on the same core; the secondary is a tap off the primary.

Bandpass Filter - a resonant filter designed to develop a voltage across its output only of the frequency range making up its bandwidth.

Bandstop Filter - a resonant filter designed to develop a voltage across its output for all frequencies except those making up its bandwidth.

Bandwidth - the range of frequencies which produce some resonant effect in both series and parallel RLC circuits. Specifically, the frequencies both below and above the resonant frequency which make the output power fall to one-half of its value at the resonant frequency.

Bank, Parallel - name given to any number of loads connected in parallel with each other.

Barrier Potential - the voltage exhibited by a PN semiconductor junction which must be exceeded before current can flow through the junction. For germanium devices the potential is approximately .3 volts and .7 volts for silicon devices.

Battery - a DC voltage source which produces a potential difference by chemical means.

Beta - the forward current transfer ratio of bipolar transistors; the collector current is controlled by the amount of base current applied.

Bias - providing DC voltage on elements of active components to ensure conduction of current through the device.

Bipolar Transistor - a three junction device, either NPN or PNP, forming an emitter, base, and collector circuit.

Branch Currents - currents that flow through parallel loads of a circuit. The branch currents must add to the value of total current in the mainline of the circuit.

Appendix G: Glossary of Electrical and Electronic Terms (cont'd)

Brushes, Motor - graphite conductors which provide continuity between the power source and motor input terminals.

Bypass Capacitor - capacitors used in electronic circuits that provide a low impedance path for AC signals so they may be removed from unwanted areas of a circuit.

Capacitance - the ability of a capacitor to store an electric charge; also, the ability of a capacitor to oppose any change of voltage across it. (Symbol C, unit farad.)

Capacitive Reactance - opposition to AC due to the action of the electrostatic field of the capacitor when it is charging and discharging in an AC sinusoidal circuit. (Symbol XC, unit Ohm.)

Capacitors - two conductors separated by an insulator or dielectric. Capacitor types are determined by the dielectric materials used in their construction.

Charge - charge carriers at rest, such as when electrons are stored in the dielectric of a capacitor.

Charge Carriers - when set in motion constitute an electric current; most common charge carrier is the electron flowing through solid conductors. However, ions are charge carriers of current in liquids and gasses and holes constitute current flow in P-type semiconductor material.

Choke - an inductor with a high impedance path to high frequency AC signals; the AC will not flow through the device.

Circuit, Electric - must have a source of potential difference, either DC or AC; a path for current flow, usually solid conductors; and a load to dissipate power and perform useful work.

Conductance - the reciprocal of resistance. A measure of how easily current flows through a resistance. (Symbol G, unit Mho or Siemen.)

Conductors, Wire - used to provide a path for current flow between voltage source and circuit loads. As length increases, resistance increases; more of the source voltage is dropped across the conductor and less is delivered to the load.

Coulomb - usually used to express current or charge; such as 6.28×10^{18} electrons equals one ampere.

Coupling - means of providing a signal path from one electronic circuit to another, such as from the output of one amplifier stage to the next. Common coupling circuits are direct coupling, RC coupling and transformer or impedance coupling.

CRT - cathode-ray tube or picture tube, used for television and oscilloscopes. Electron beam(s) scan a phosphorescent layer on the inside face of the tube tracing out visible images.

Current - charge carriers in motion, the most common being the electron in motion through solid conductors, ions flowing in liquids or gasses and holes flowing through P-type semiconductor material.

Current Divider - name given to circuits with parallel load connections since the source current must divide among all parallel loads.

Cycle - the number of complete sinusoidal waves per second produced by an AC generator, such as 60 waveforms per second equal 60 HZ.

Damping Resistor - in a parallel AC RLC circuit, is used to reduce the Q of the circuit and broaden the bandwidth.

Digital Meter - a non-scaled meter with a numerical display for a readout.

Diode - an electronic device that allows current to flow through it in only one direction.

Appendix G: Glossary of Electrical and Electronic Terms (cont'd)

Direct Current - current which flows from one source potential through all circuit loads and back to the opposite source potential. Negative electrons are repelled away from the negative terminal of a battery and attracted toward the positive terminal of the battery.

Dissipation, Power - when circuit loads perform useful work. Power may be dissipated in the form of heat, light or electromagnetic means.

Doping - process of adding impurity elements to semiconductor materials to determine the material's conductivity.

Eddy Currents - current which flows through the core of an inductor due to electromagnetic induction. This is an unwanted effect and can be minimized by using laminated core sections well insulated from one another.

Effective or RMS Value - called the root-mean-square value of an AC sinusoidal wave, is the amount of AC voltage and/or current that will do the same amount of work as a corresponding value of DC. 120 volts rms AC will do the same work as 120 volts DC.

Electricity - the flow of electrons, ions, or holes.

Electrolytic Capacitor - a capacitor with a chemical dielectric. These capacitors must be connected in a circuit with proper polarity or the electrolytic expands and the capacitor bursts.

Electromagnetic Induction - an electric voltage is induced whenever there is relative motion between a magnetic field and solid conductors. Generator action consists of rotating conductors within a stationary magnetic field and transformer action consists of stationary conductors and a magnetic field in motion.

Electromagnetism - a coil of wire exhibits the properties of a permanent magnet when direct current flows through it.

Electromotive Force - another name for voltage. The potential difference which must exist across a load before current can flow through it.

Electrostatic Field - a magnetic field that exists between electrically charged objects, such as between electrons and protons in an atom or between the plates of a capacitor that has been charged.

Ferrites - insulators that exhibit properties of ferromagnetic materials. Commonly used as inductor core material, such as the antenna coil of an AM radio.

Ferromagnetic Materials - such as iron or steel, easily concentrate magnetic flux lines and have a high permeability.

Field-Effect Transistor - a three junction device, either N-channel or P-channel, forming a source, gate, drain and substrate.

Figure of Merit or Q - the quality of an inductor is a ratio of its reactance to its internal resistance. The higher the Q value, the higher is the quality of the inductor, meaning an inductor is usually capable of producing much more reactance than it has internal resistance.

Filters - passive or active configurations used to separate currents of different frequencies.

Flux - magnetic lines of force surrounding a permanent magnet or produced by electromagnetic or electrostatic means.

Appendix G: Glossary of Electrical and Electronic Terms (cont'd)

Frequency - the number of cycles per second determine the frequency of an AC sinusoidal wave. (Symbol F, unit Hertz.)

Full-Wave Rectifier - a circuit that converts AC into pulsating DC with an output frequency twice that of the input frequency.

Fuse - a device to protect electric circuits from faults, most commonly a short-circuit condition where current increases many times its normal value in the circuit.

Gain - an electronic circuit that has the ability to increase either voltage current or power is said to have gain; amplifiers are designed for this purpose.

Generator - a device that converts mechanical energy into electrical energy.

Grid(s) - elements inside vacuum tubes that control the flow of electrons through the tube. Most common grids are called control, screen, or suppressor.

Ground - usually a common connection point in an electric circuit which may or may not be grounded.

Half-Power Points - frequencies which define the bandwidth of a resonant RLC circuit; when power is one-half the value it is at the resonant frequency.

Half-Wave Rectifier - a circuit that converts AC into pulsating DC with an output frequency equal to the input frequency.

Henry - the unit of inductance; one henry is the amount of inductance that allows one volt to be induced when the current changes at the rate of one ampere per second.

Hertz - the unit of frequency; one hertz is equal to one complete sine wave.

High-Pass Filter - a filter circuit that will develop an output for high frequencies while blocking or attenuating low frequencies.

Hole - the absence of an electron in P-type semiconductor material; thought to be a positive charge which moves toward a negative potential.

Hysteresis - when the domains of a magnetic material lag behind the magnetizing force. Friction and heat, unwanted effects, are the results.

Impedance - the total opposition to AC due to resistance, inductive, and capacitive reactance, or the term used to describe the amount of opposition an electric circuit or device exhibits. (Symbol Z, unit Ohm.)

Induced Voltage - is produced whenever there is relative motion between conductors and magnetic flux.

Inductance - the ability of an inductor to induce voltage; also, the ability of an inductor to oppose any change of current flowing through it. (Symbol L, unit Henry.)

Inductive Reactance - the amount of opposition to AC due to the action of the electromagnetic field of an inductor. (Symbol XL, unit Ohm.)

Inductors - coils of wire with or without magnetic cores. Inductors may be single coils or multiple-coils, such as a transformer.

Insulators - materials that restrict the flow of current through them.

Appendix G: Glossary of Electrical and Electronic Terms (cont'd)

Integrated Circuits - semiconductor devices made up of many active and passive components to form a complete circuit in one small device.

Interelectrode Capacitance - capacitance which exists between the elements of active devices, such as between the plate and grid of vacuum tube triode or between collector and base of bipolar transistor. This capacitance becomes a problem when the device operates at high frequencies and positive feedback from output to input can cause an amplifier to begin to oscillate.

Ions - are charged atoms. A negative ion has gained electrons from other atoms and a positive ion has lost electrons to another atom.

j-Operator - term used to express the direction of rotation of a vector quantity. +j means 90 degrees counterclockwise and -j means -90 degrees in a clockwise direction.

Load Line Analysis - graphical means of determining the operating point of an amplifier using the characteristic curves for the device (transistor or vacuum tube).

Low-Pass Filter - a filter circuit that will develop an output for low frequencies while blocking or attenuating high frequencies.

Mainline - that part of a parallel circuit which includes the source and circuit path to where current divides. This is where total current can be measured in the circuit.

Microwaves - high frequency RF with short wavelengths.

Mutual Inductance - when a voltage can be induced from one coil to another that is placed close by; especially between the primary and secondary coils of a transformer.

Oscillator - an electronic circuit that produces an AC voltage and current of a specific frequency. Most common oscillators use parallel resonant circuits to produce their frequency of operation.

Passive Components - resistors, inductors, and capacitors that are used in electric circuits to control voltage and current but do not provide gain.

Peak-to-Peak Value - of a sinusoidal AC waveform, is the value from 90 degrees to 270 degrees. P-P values can be determined with the aid of a oscilloscope.

Peak Value - of an AC sinusoidal waveform, is one-half the peak-to-peak value.

Period - of an AC sinusoidal waveform, is the time required for one cycle to complete itself. (Symbol T, unit second.)

Permeability - a measure of how easily a magnetic material (such as iron) will concentrate magnetic flux. For use in inductors, the higher the permeability of the core the better quality of the inductor.

Permittivity - a measure of how easily an insulator will concentrate magnetic flux. For use as dielectrics in capacitors, the higher the permittivity of the dielectric the more charge the capacitor can store.

Phase Angle - the difference in time between total voltage and total current in AC, RL, RC and/or RLC circuits.

Photoelectricity - the ability of some materials to produce a potential difference when struck by light.

Appendix G: Glossary of Electrical and Electronic Terms (cont'd)

Potential Difference - another name for voltage/electromotive force.

Potentiometer - a variable resistor used to control voltage.

Radian - a system of measure used in AC circuit analysis. One radian is equal to 57.3 degrees of angular measure.

Rectifier - an electronic circuit used to convert AC into DC.

Resistance - opposition to current flow, either AC or DC.

Resistor - a passive component used to restrict current or to divide source voltage.

Resonance - the condition of an AC RLC circuit which makes XL equal to XC at one specific frequency.

Rheostat - a variable resistor used to control circuit current.

Scientific Notation - used for expressing very large or very small electric quantities (voltage, current, resistance, and power). The most commonly used are meg, kilo, milli, micro, and pico.

Short Circuit - a condition in a circuit where the normal load resistance or impedance is replaced by a much lower resistance or impedance causing circuit current to increase many times.

Solenoid - a long thin air-cored coil.

Susceptance - the reciprocal of reactance. A measure of how easily current flows through a reactance. (Symbol B, unit Mho or Siemen.)

Thermal Runaway - the condition of a transistor when the Beta increases due to heat and the collector current increases with the increase in Beta. Unless checked, the collector current can become great enough to destroy the collector-base junction and ruin the transistor. An emitter resistor, causing DC negative feedback, is often employed to control the rise of collector current due to increases in Beta.

Thyristor - any device that is in the family of controlled rectifiers, such as the SCR, Triac, Diac and the thryratron vacuum tube.

Transformer - an inductor with primary and secondary windings. Three basic types exist: step-up, with more turns in the secondary than in the primary, step-down, with more turns in the primary than in the secondary, and isolation, with equal turns making up the primary and secondary windings.

True Power - the power dissipated by the resistive loads in an AC, RL, RC, and/or RLC circuit.

Tuned Circuits - RLC circuits that may be made resonant by physically changing the value of either inductance or capacitance to make XL equal XC; such as the AM radio being tuned to a specific radio station frequency.

Varactor - a diode which exhibits capacitance when it is reverse-biased changing the thickness of its depletion region. The greater the amount of reverse bias, the more capacitance the diode exhibits.

Volt-Ampere-Reactive Power - that power dissipated by reactive loads of an RL, RC, and/or RLC circuits.

Voltage Drop - that portion of the source voltage that exists across a circuit load, necessary for current to flow through that load.

Appendix G: Glossary of Electrical and Electronic Terms (cont'd)

Wavelength - the distance an electromagnetic wave will travel through space. The higher the frequency of the wave the shorter is the wavelength.

Zener Diodes - also known as voltage-reference diodes. They are silicon diodes designed for a specific reverse breakdown voltage making them useful as voltage regulators.

Appendix H: Significant Events in Electricity and Electronics

1746 Pieter Van Musschenbroek - invented the Leyden Jar, the first practical capacitor making it possible to store electricity. Before this time only static electricity was known to exist.

1752 Benjamin Franklin - proved that a lightning discharge is electricity. Formalized the theory of positive and negative charges as the first explanation of electricity.

1800 Alessandro Volta - discovered electrochemical effect, invented the first continuous source of electricity, the battery.

1820 Hans Oersted - discovered electromagnetic effect; found that a magnetic field surrounds a conductor when current flows through it.

1825 Andre Ampere - developed mathematics of dynamic electricity; determined the relationship between electrical current intensity and the strength of the magnetic field.

1827 George Simon Ohm - defined the relationships among voltage, current and resistance; Ohm's Law.

1830 Joseph Henry - discovered self-inductance and developed the first efficient electromagnet.

1831 Michael Faraday - discovered mutual inductance and proposed the magnetic lines of force theory. Faraday was the first to use magnetic fields to produce mechanical motion; the first electric motor.

1837 Samuel Morse - developed the first electric telegraph and code for sending messages over long distances. First transmission line was between Washington, D. C. and Baltimore, Maryland.

1875 Alexander Graham Bell - invented the first practical telephone. At about the same time, others were inventing basic transducers; the carbon microphone and the loudspeaker.

1883 Thomas Edison - added another electrode to his light bulb and observed a current flow through the bulb; coined the Edison Effect.

1887 Heinrich Hertz - first to demonstrate electromagnetic radiation through space; basis for the "wireless" form of communication.

1895 Guglielmo Marconi - used a long wire antenna and developed a practical radio system for long distance communication.

1895 John Ambrose Fleming - discovered that Edison's bulb with the extra electrode would serve as a "detector" for the wireless; invented the vacuum tube diode.

1900 R. A. Fessenden - used a telephone circuit to transmit human speech on radio waves for the first time.

1906 Lee DeForest - placed a control grid in the diode vacuum tube and invented the first vacuum tube amplifier circuit; called the "Audion," now known as the triode vacuum tube.

1907 First regular radio broadcasts began from the the DeForest Radio and Telephone Co., New York City.

1908 Campbell Swinton - outlined a method of electronic scanning; the forerunner of the cathode-ray tube.

Appendix H: Significant Events in Electricity and Electronics (cont'd)

1912 R. A. Fessenden - invented the heterodyne radio system.

1915 Hanson Benedicks - laid the basis for the integrated circuit by discovering that the germanium crystal can be used to convert AC into DC.

1918 H. Abraham and E. Block - invented the vacuum tube multivibrator circuit clearing the way for the use of vacuum tubes in computers.

1919 The superheterodyne radio receiver was mass-produced for the first time.

1926 H. J. Round - introduced the screen grid to the triode vacuum tube making an amplifier circuit that solves the problem of static interference and greatly improves the stablity of high-frequency reception.

1926 H. A. Wheeler - invented the automatic volume control circuit for the superheterodyne radio receiver making it unnecessary to readjust the receiver's volume control when tuning across the dial.

1927 H. S. Black - discovered the principle of negative feedback; by placing part of an amplifier's output back to its input, distortion is reduced.

1927 Philo Farnsworth - devised the first completely electronic television system.

1928 Holst and Tellegen - introduced the screen grid in the tetrode vacuum tube to create the pentode vacuum tube with further improvement over the tetrode for high frequency amplifier operation by reducing the amount of interelectrode capacitance.

1931 First regular television broadcasts began from the west coast station W6XAO operating on the VHF band.

1933 Edwin Armstrong - perfected frequency modulation which overcame the problem of natural and man-made radio interference.

1937 Howard Aitken - began work on digital computer; by 1944 developed the Mark I, the first fully automatic computer for mathematical calculations.

1940 Peter Goldmark - developed the first fully electronic color television system.

1946 ENIAC (Electronic Numerical Integrator and Calculator) was built at the University of Pennsylvania. This digital computer was the first to use electronic pulses. With 18K vacuum tubes, it performed 5K calculations/second.

1948 William Shockley, Walter Brattain and John Bardeen - at Bell Labs, invented the first semiconductor transistor from a germanium crystal.

1950 The Vidicon television camera tube was developed by RCA Corporation which utilized the principle of photoconductivity by which light of different intensities produced electrical signals of varying amplitudes.

1956 Alexander Poniatoff - demonstrated his Ampex video tape-recorder which produced a picture almost indistinguishable from a live television broadcast.

Appendix H: Significant Events in Electricity and Electronics (cont'd)

1956	The first transistorized computer was completed by Bell Telephone Laboratories, consuming far less energy and being more reliable than the vacuum tube computers formerly in use.
1959	Hoeni - developed the planar process for integrated circuits, creating transistors on the surface of a wafer of silicon.
1960	Nick Holonyak, Jr. - invented the light-emitting diode (LED) to become the most popular display for pocket calculators and electronic watches.
1962	Telstar, the first communications satellite, was launched, linking the USA and Europe for periods of up to 20 minutes a day.
1965	The first electronic telephone exchange was installed at Succasunna, NJ.
1967	Experimentation with laser beams to carry TV pictures began, with a capacity to carry more information and much faster than radio waves.
1969	Bubble computer memory was developed; each device contains hundreds of thousands of bubbles which retain data even if the power supply is cut off.
1971	The microprocessor, the world's first computer on a chip, was introduced by the Intel Corporation which revolutionized the computer industry.
1972	Large-scale integration techniques were developed by IBM which made it possible to produce 100K transistors on a single chip of silicon only a few millimeters square.
1974	The first programmable pocket calculator was developed by Hewlett Packard which can be programmed to solve scientific, engineering, and statistical problems.
1976	The personal computer market exploded with the introduction of the APPLE microcomputer.
1977	Bell Telephone Company was the first to transmit television signals using optical fibers, a more efficient and economical means of conducting signals.
1977	The video cassette tape recorder was developed by Phillips of the Netherlands.
1980	John Barker - designed self-repairing microchip circuits in which functions of a damaged circuit are taken over by a neighboring circuit. These chips can perform multiple functions depending on the way they are connected.

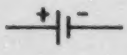
Appendix I: Electrical and Electronic Symbols

AMPLIFIER
Two inputs

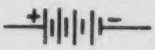
ANTENNA
General

Dipole

BATTERY
One cell



Multicell



CAPACITOR
General

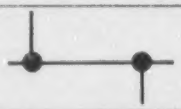
Polarized
(electrolytic)

Variable or
Adjustable

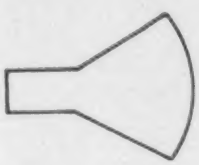
Crossing not
connected

Junction (Avoid if
possible. Use next
symbol.)

Junction

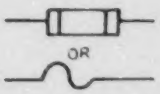


C.R.T.



CRYSTAL
Piezoelectric

FUSE



GROUND
Wire is bonded to
chassis.

Chassis or frame
connection

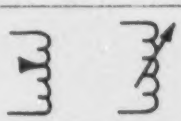
Incandescent
filament

INDUCTOR
General

Magnetic core

Tapped

Adjustable



MACHINE, ROTATING
General

Generator

Motor

Appendix I: Electrical and Electronic Symbols (cont'd)

METER (INSTRUMENTS)
General

Example:
milliammeter

MICROPHONE

RECTIFIER
Semiconductor
rectifier diode

RESISTOR

SPEAKER
General

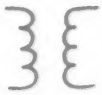
SWITCH
Single-throw (ST)

Double-throw (DT)

Double-pole,
Double-throw (DPDT)

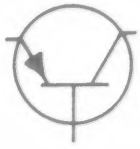
Push-button

TRANSFORMER
General



Magnetic core

TRANSISTOR
PNP type



NPN type

Unijunction
N-type base

Unijuntion
P-type base

Field-effect
N-type base